COMPUTERS AND AUTOMATION

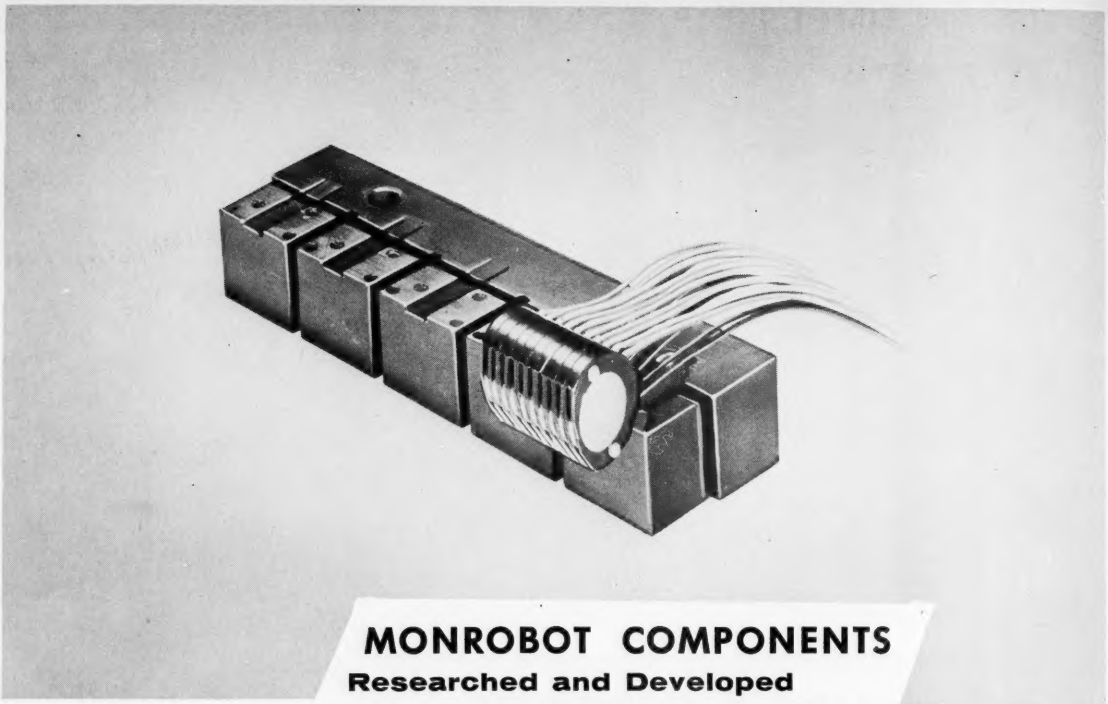
YBERNETICS • ROBOTS • AUTOMATIC CONTROL

Mathematics, the Schools, and the Oracle
. . . Alston S. Householder

Linear Programming and Computers
. . . Chandler Davis

The Application of Automatic Computing Equipment to Savings Bank Operations
. . . . R. Hunt Brown

The Book Reviewer
. . . Rose Orente



A bank of Monrobot Ring-type Heads on adjustable mounting

MONROBOT COMPONENTS

Researched and Developed for the Electronics Field

Monroe, for many years a leader in the design and production of desk calculators, is devoting its experience and research facilities to developing not only digital electronic computers but also component parts that are unique for their originality of design and numerous advantages.

The components, illustrated here, are Monrobot Ring-type Read/Record Heads and an adjustable fixture for magnetic drum memory systems.

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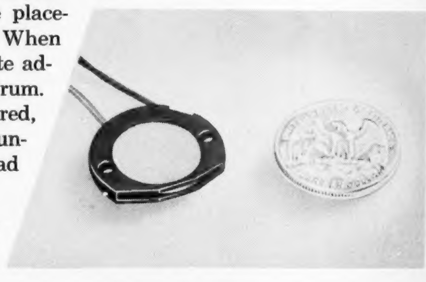

Monrobot Ring-type Head — small, compact

Monrobot components of this kind offer the user of electronic equipment many worthwhile benefits. There's a lot to the Monrobot component story that's worth investigating. Inquiries are invited.

MONROBOT

MONROE CALCULATING MACHINE COMPANY

MONROBOT LABORATORY

MORRIS PLAINS NEW JERSEY

COMPUTERS AND AUTOMATION

CYBERNETICS ROBOTS AUTOMATIC CONTROL

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THE EDITOR'S NOTES

THE PLACE OF COMPUTERS IN SOCIETY

The last issue of "Computers and Automation" showed in the "Who's Who" a list of about 7500 people interested or believed to be interested in automatic computers. This number is probably twice as great as the total number of persons interested in automatic computers about three or four years ago. An inspection of a sample of the Who's Who records shows that entrants into the computer field are about evenly divided between those entering 1951 and later, and those entering 1950 and earlier, confirming our guess. Certainly, the subject of automatic computers is drawing more and more people into the field; and it is not too much to estimate that in another three or four years the number of people in the field will double again.

Why is this tide happening?

One reason is that automatic computers have actually produced concrete and worthwhile results to difficult problems. Many of these results are clothed in military or industrial confidence; but one famous problem actually done on the IBM Electronic Selective Sequence Calculator (now dismantled) was the accurate astronomical computation of the position of the moon every six hours from the year 1600 to the year 2000.

Another reason is that government, business, industry, and scientific and university laboratories have all become convinced of the value of these machines. They have poured in money for research, development and orders for machines. In addition, some organizations were bold and ventured to purchase early models of machines; and some of these macines have worked efficiently and well. The Bureau of the Census liked its first Univac so much that it has bought a second; the organization that pioneered with punch card machines 1885 to 1895 has pioneered again with automatic computers 1945 to 1955.

A third reason is that automatic computers constitute an essentially new power in the hands of men. Whenever some improvement in the tools of society greatly changes a factor of advantage, men become justifiably excited. An automatic computer increases the power to handle information by a factor of 10,000 to 100,000; that is exciting; and men are drawn into this new field as in 1848 men were drawn to California to seek gold.

Another reason is that an essential ingredient of automation is the middle part, the thinking part, the controlling part, -- in between the sensing organs that the instrumentation scientists and engineers are interested in, and the acting organs that the makers of valves, monorails, transfer machines, machine tools, etc., are interested in. Though the thinking part of automation is not yet very advanced, still it is bound to develop more and more. That is why "Computers and Automation" defines its territory as "computers and their applications and implications including automation".

A final reason perhaps is that automatic computers are deeply challenging to the desire of man to be the preeminent rational being. Many competent investigators and scientists consider that the new machines do think. At the very least, these machines provide an almost magical power over a great many thinking operations; and no man can surely prophesy what are the limits of their powers. It seems quite likely that over the next 50 to 100 years every intellectual process will be done better by a machine than by the best endowed and educated human being. If this may happen, why not become associated first-hand with a development so disturbing and so powerful?

The place of computers in society seems destined to be like the place of brains in a man's life.

SPECIAL ISSUES OF "COMPUTERS AND AUTOMATION"

The last issue of "Computers and Automation", June, 1955, was a special issue: "The Computer Directory, 1955", 164 pages, containing: Part 1, Who's Who in the Computer Field; Part 2, Roster of Organizations in the Computer Field; and Part 3, The Computer Field: Products and Services for Sale.

The next two special issues will be December, 1955, and January, 1956. The December issue will be mainly devoted to useful information for people who have been in the computer field for some time: a "Glossary of Terms", and also cumulative editions of other pieces of reference information. The January issue will be mainly devoted to useful information for people who have newly entered the computer field: an introduction to computers (and to "Computers and Automation"); and reprints and revisions of some of the more introductory articles and papers that "Computers and Automation" has published.

MATHEMATICS, THE SCHOOLS AND THE ORACLE

Alston S. Householder
Oak Ridge National Laboratory, Oak Ridge, Tenn.

(Presented to the mathematics teachers of the Middle Section, Tennessee Education Association, Nashville, Tenn., Oct. 23, 1953; reprinted with permission from the "The Mathematics Teacher", May, 1955)

I welcome the opportunity to speak to teachers of mathematics, because I believe that what I can say can be of interest to you and may be helpful. Mathematics is my vocation. I might add that it is also my avocation. Formerly I was engaged in the teaching of it, and now I am engaged in the practice of it. There was a time, when I was somewhat younger, when in order to make a living by mathematics alone one had to teach, and although many professions demanded some knowledge of mathematics, there were very few openings outside the teaching profession for mathematicians as such.

Today the situation is quite different. As an indication of the change, consider the personal items in a recent issue of the American Mathematical Monthly. On one of the several pages there are items concerning 17 individuals. The following is a list of the professional connections, other than academic, of these indivudals: The Goodyear Aircraft Corporation, Sperry Gyroscope Company, Oak Ridge National Laboratory, the Airforce Cambridge Research Center, Convair, Fairchild Aircraft Division, Naval Ordnance Test Center, New England Mutual Life Insurance Company, White Sands Proving Ground and the Ballistic Research Laboratories. My only reason for making the list from this page rather than some others was that it named Oak Ridge. Otherwise there is nothing unusual about it. The names are in alphabetical order, ranging from N to Y, on this page. As you doubtless know, the American Mathematical Monthly is the official journal of the Mathematical Association of America, an organization devoted to the interests of collegiate mathematics.

There is a difference, of course, between the utilization of mathematics, and the utilization of the services of mathematicians. The extent to which non-mathematicians must draw upon their mathematical training is not easy to measure. But the list of organizations I have just given provides some indication of the extent to which there is need for the services of mathematicians in the conduct of our society today.

There are those to whom this state of affairs may appear to be a weird paradox, representing at best (or rather, in their eyes, at worst) a stage of transition in our technological development. A news item from the local press in Oak Ridge illustrates what I mean. The item quotes from a statement made by an Oak Ridge citizen in a public meeting. Before reading it I want to assure you that I have not snatched the words out of context. I heard the entire speech, which lasted for perhaps five minutes or so, and the words I shall quote represent a fair summary of what he had to say: "Personality is much more important than grades.. The three R's are only tools. Arithmetic? Why they got machines to do all this mathematics!"

Now it just happens that we have at the Oak Ridge National Laboratory, where I work, one of these machines to do all this mathematics. I am in charge of a group of about 20 mathematicians whose responsibilities include the operation of this machine. It is our job, in other words, to get the machine to produce the mathematics. I thought it might be of some interest to you if I try to tell you briefly how it operates, and how we operate. If I am able to give you an intelligible account, perhaps you can then judge for yourselves to what extent we may expect technological unemployment among mathematicians in the near future.

The name of this machine is ORACLE, for Oak Ridge Automatic Computer and Logical Engine. With all due modesty I can say that it is one of the fastest and, for mathematical purposes, one of the most versatile of all machines now in existence. I mention this, not so much to put in a plug for Oak Ridge as to make it clear that whatever I may say or imply about the limitations or shortcomings of the ORACLE apply with equal strength, to any other machine you might name.

Just what, then, can the ORACLE do? It can add, subtract, multiply and divide, and essentially that is all. It is true that it can perform a number of simple non-arithmetic operations, which I shall describe shortly, but these non-arithmetic operations, generally spoken of as logical operations, are relatively unimportant in themselves. They are incorporated primarily to expedite the performance of the arithmetic operations.

I think it should not be hard to see why they are necessary. If you use an ordinary desk calculator, every time you wish the machine to perform an operation you must at least push the appropriate operation button; for almost every operation you must also enter at least one number, and generally two; and following many, if not most, of the operations, you must copy down the result. Sometimes, as when adding a string of products, a result is merely intermediate and can be left in the machine to be further modified or operated upon. But in any event, the operator has at least one thing to do, and usually several, before any operation can be carried out by the machine.

The ORACLE however, is able to multiply two numbers in about one two-thousandth of a second; it can add in one twenty-thousandth of a second. Obviously such phenomenal speeds would be of no use whatever if the operator had to make any motions at all to set off each operation. This

speed is useful only because the machine itself can, in effect, push its own buttons.

This is the first point I want to make, then, that the ORACLE, like all the other so-called electronic brains, is actually a high speed arithmetic machine, and all its non-arithmetic operations are subservient to the arithmetic ones. In saying this I am certainly not intending to belittle what is indeed an amazing achievement of contemporary technology. But one should understand the machine as it is and not be misled by romantics.

Next, it must be clear that though the machine is capable of pushing its own buttons at the proper times, so that all operations required for any given calculation are performed in the right order, nevertheless the machine itself is not endowed with an understanding of when these times are to be, but can only go by the information supplied by the operator. It can remember a long series of instructions. Indeed, it can operate for minutes, or hours, or even indefinitely, if nothing goes wrong, after a suitable set of instructions have been given it. But the instructions must be given, and the burden falls back upon the human operator to plan in advance every step the machine is to take, to supply the data upon which it is to operate, and to present all this to the machine at the outset.

This is the subject I should like now to discuss with you in some little detail. Imagine that the ORACLE is at your disposal and you have a problem you wish it to solve. What must you do, precisely, in order to get the ORACLE to give you answers to your problem? In a brief lecture I certainly cannot go into all details, so I shall try merely to illustrate by means of a fairly simple but fairly typical computation. Suppose that somewhere in the course of your computation it is necessary to extract a square root. Clearly one does not employ so elaborate a machine merely to extract a square root, and I am supposing only that this is one small part of the over-all computation. How do we plan for the execution of this part?

I shall have to describe very briefly certain features of the machine. It is convenient to distinguish two major constituents, the memory and the arithmetic unit. The arithmetic unit is, of course, that portion of the machine that performs the actual arithmetic operations, and that corresponds most closely to a desk calculator. In this are two registers which correspond to the dials of a desk calculator. Before an arithmetic operation is performed, one of the operands must be present in one of these registers, just as, say, the dividend must appear on one of the dials of a desk machine before the division begins. Likewise, after the operation is completed, the result will appear in one of these registers.

The memory retains all the input data for the problem, all the instructions for the problem, all the instructions for solving it, all the intermediate results obtained at one stage and required at a later one, and all the final results. The memory is divided into a number of cells. Each cell can store a set of binary digits, since this machine uses a binary base rather than a decimal one. To be precise, a cell can store 40 binary digits. A set of 40 binary digits is called a word, and a word may represent a number expressed in the base 2, or it may represent a pair of commands. The cells are numbered in sequence beginning with 0, and the number of a given cell is called its address. The address of a cell is always the same and must, of course, be distinguished from the contents of the cell, that is, the word currently stored in the cell, and which may change many times as the computation proceeds.

As the machine operates, it normally goes from one cell to the next, interpreting the contents of each cell when it gets there as representing a pair of commands; it performs these commands and passes to the next cell. However, it is possible to give a special command, called a transfer, which causes the machine to go next to some specified cell instead of proceeding to the next cell as usual. In fact, one can give a conditional transfer command which causes the machine to interrupt the normal sequence only if a certain condition is fulfilled. This makes it possible to cause the machine to repeat a given sequence of operations any specified number of times. This is an extremely important feature, and without it the great speed would be of very little use and might even be a handicap.

Finally it should be explained that the machine, in effect, thinks that all numbers lie between + 1 and -1. Suppose the number ½ is in cell number 10, and 3/4 is in cell number 11. Suppose you ask the machine to add the numbers in these cells 10 and 11 and then to put the result in cell number 12. There is no machine word for 1¼, which is the true sum, and cell number 12 will receive instead the word for -3/4. And if you ask the machine to divide the number in cell number 10 into the number in cell number 11, and to put the result in cell number 13, the machine will go through certain operations and put a number into cell number 13, but it will not be the true quotient 1½. When you are planning a computation for the ORACLE, therefore, you must take care that everything is properly scaled and that all results will lie on the proper range.

With this understanding, we can get on with the problem. There is a number which we may call _a_, which the machine will have computed at some stage of your computation, and you are going to need the square root of this number. If the computation has been properly planned, then the machine will have placed the number _a_ in a definite, prearranged, cell in the memory, and you will know the address of the cell. To be specific, suppose _a_ has been placed in cell number 100. You therefore wish the machine at the appropriate stage of the computation to find the square root of the number which will at that time be stored in cell number 100.

Of course, the machine knows nothing about square roots. It understands only addition, subtraction, multiplication and division. It is up to you to devise a sequence of operations of this type that will lead to the production of the square root of _a_, or of a sufficiently close approxima-

tion thereto. And this sequence must be set forth in complete detail in the language the machine understands.

There are several ways of calculating square roots, but the simplest and best from all angles seems to be the use of Newton's method applied to the equation $x^2 - a = 0$. It is a method of successive approximation. If x_0 is some initial approximation, not too awfully far off, then $(x_0 + a/x_0)/2$ is a better one. We can call this x_1, do the same with x_1 as was done with x_0, and come out with an approximation that is still better. For example, suppose $a = 0.25$. Now you and I know the answer to this at the start, but the machine does not. Suppose $x_0 = 1$. Then $x_1 = (1 + a)/2 = 0.625$, $x_2 = 0.5125$, and $x_3 = 0.5001$. Although the initial approximation was quite poor, in three steps the error is reduced to 1 in the fourth place.

Now you can, of course, be sure that the number a to be found in cell 100 is less than 1, and hence will have a square root that is less than 1. One can prove mathematically then that if $x_0 = 1$, then every x_i in the sequence as defined mathematically will be less than the one which came before, and will be greater than the true square root of a. Furthermore, by continuing long enough one can obtain an x_i that differs from the true square root by less than any preassigned positive quantity. In other words, though one will never find an x_i, in the sequence as defined mathematically, that is exactly equal to the true square root, nevertheless one can find an x_i that deviates by as little as one may choose.

These statements are rigorously correct for the sequence as defined mathematically by Newton's method. But we must now note the fact that in general the machine is not able to give us quite the same sequence. The trouble is that the true quotient of a divided by x_i may, and usually does require infinitely many digits, and these would require an infinite time to obtain. But the machine can represent only a finite number of digits and we have only a finite time at our disposal. Hence each quotient, and therefore each term in the sequence, will differ slightly from the quantities that are defined mathematically.

The questions then arise: How many properties of the mathematical sequence will be possessed by the numerical sequence actually obtained by the machine, and, in particular, how close will the numerical sequence take us to the true square root? Clearly there is a limit to the attainable accuracy. For if the true square root is not rational, it is certainly not expressible exactly in any finite number of places. There is, however, a unique number that is expressible in the number of places carried by the machine, and that is closer to the true square root than any other such. Is it possible that this number will occur as a term in the numerical sequence? And if so can the machine recognize it and be made to stop on that term?

These questions are by no means merely academic, and their answers are by no means obvious. The fact of the matter is, that although the mathematical sequence is perfectly well defined, I have not yet given a proper and unequivocal definition of the numerical sequence. There are several ways that one might define the numerical sequence, and it turns out that these ways do not always lead to quite the same sequence.

Consider the mathematical sequence once more. Given any term s_i, one forms the next term by the formula $(x_i + a/x_i)/2$. This suggests that one divide a by x_i, add x_i to the result, and then take half of the sum. But remember that our numbers in the machine must be kept less than 1, whereas if a is close to 1, then $x_i + a/x_i$ will certainly be greater than 1. This will not do.

So we might consider next dividing each term by 2 before we add, instead of adding and then dividing the sum. This is a possible way to do it, but the extra division has two slight disadvantages. One is that it requires extra machine operations and correspondingly more machine instructions; the other is that we introduce an extra small error in rounding off after the division. Though not critical, the objections invite further consideration.

You recall that the mathematical sequence is always decreasing. The numerical sequence cannot decrease forever, but one might expect it to decrease at the start. It seems reasonable to suppose that when at some stage the numerical sequence has ceased to decrease, then we have probably come as close as the machine will take us to the true value. This suggests that we calculate the decrement at each step, subtracting this from the previous term so long as it keeps the same sign, and stopping when the decrement vanishes or changes sign. Now the decrement turns out to be $(x_i - a/x_i)/2$. Thus, in the previous example, from $x_i = 0.625$ we would have the machine calculate the decrement $\Delta(x_i) = 0.1125$ and then obtain $x_2 = 0.625 - 0.1125 = 0.5125$. Since x_i and a/x_i are both less than 1, their difference is also less than 1, and we avoid both the illegitimate addition and the extra division.

Even now, however, the numerical sequence is not completely defined. We could divide a by x_i and subtract the quotient from x_i; or we could divide $-a$ by x_i and add the quotient to x_i. In either case we would take half of the result as the required decrement. With either scheme we would introduce a conditional transfer instructing the machine to subtract this decrement from x_i and repeat, if the decrement is positive, but otherwise to go on to something else since it has then found as close an approximation as it can get. A third possibility, not apt to suggest itself immediately, is to divide $-a$ by x_i, subtract from $-x_i$, and then divide by 2. This gives the negative of the decrement and is to be subtracted from x_i if negative. Even this does not exhaust the list of possibilities, but perhaps it is sufficient for illustrating the point. When one of these three possible modes of procedure is selected, then, and only then, is the numerical sequence completely defined.

It turns out that these three procedures actually define three different sequences. The third one is somewhat preferable to the first and either is preferable to the second. When the third one

is used, the decrement never changes sign but ultimately vanishes. When this happens the approximation is for most values of a the best possible.

We have now selected a precise sequence of arithmetic operations for the machine to perform in order to find the square root. The rest is routine. We decide in what specific memory cell we wish to send the final approximation x, and in what part of the memory we shall store the instructions for doing the computation. Then we write these down, one after the other, in the language of the machine. It takes 16 distinct commands, or 8 words. Two of these commands are transfers. One transfer command tells the machine where the instructions for the next task are to be found after the decrement has become equal to zero. The other one tells the machine to go back to the beginning and repeat the cycle when the decrement is not yet zero. In the worst case the machine will go through the cycle 39 times before it finishes.

I have chosen the square root for my illustration because it is quite simple, but nevertheless fairly typical. Whether it is the 16 commands for finding a square root, or the several hundred commands for inverting a matrix, or the one or two thousand commands that might be required for finding the numerical solution of a system of differential equations, they must be explicit to the last detail, for the machine has no imagination whatever, and they must be based upon a careful analysis of the problem at hand.

In one respect the square root problem is extremely atypical. We can say definitely that the answer is at worst second best, and we can lay down very narrow limits of error. Generally, however, the errors due to rounding off the results of multiplication and division build up in a manner that is difficult to analyze so that our estimates of them are only very crude. Sometimes even the best schemes we have been able to devise still leave us with results that may be not even second or third best, at least without making the sequence of instructions far more elaborate than is ordinarily worth while.

In this technological age, machines have created for us material comforts undreamed of in times past, and they have relieved us of much drudgery, both physical and, even, mental. But no machine yet conceived can provide understanding. If the ORACLE'S performance deviates in even the slightest respect from what you expect of it, then either you have unwittingly given it incomplete or improper instructions, or else, what is possible but much less likely, something has gone wrong with the machine. Only you, and not the machine, can understand what is needed, and how the machine can get for you. This is the point I have been trying to make, perhaps laboriously, by my example of the square root.

And so, if we are told that inasmuch as there are computing machines, or thinking machines, or electronic brains, or what have you, therefore it is no longer important that students learn mathematics, we can be assured that nothing can be further from the truth. Millions of dollars are being spent every year by industry and government on the design and construction of these machines. Here again is evidence of the importance of the role played by mathematics in the operation of contemporary technology. But only the mathematical understanding of human beings can recognize and formulate the problems that require solution, can devise the methods to be used for solving them, and can interpret and apply the solutions once they are found. Our friend, whom I quoted at the outset, is laboring under a misconception that is shocking and extremely dangerous. It would undermine the foundations of the very technology that can produce and effectively utilize these machines for us to relax and expect them to relieve us of the necessity to learn and understand mathematics.

With regard to personality, which our friend considers so important, I might remark that I, too, consider it important, especially in a group such as ours which requires much teamwork. But while I would not hire someone whose personality did not strike me as reasonably good, I would not even bother to interview any person whose grades were not well above average.

Let me conclude with another brief quotation. You recall the Polish UN delegate who recently escaped from his hotel in New York. The newspapers quote him as saying that Soviet grand strategy is based upon "the progressive destruction of the cultural, economic, and political foundations of the free world." Among the cultural and economic foundations of the free world, let no one underrate the importance of mathematics. The obvious place to attempt to undermine these foundations is in the schools. It is up to us whether we will withstand the attack or assist it.

END

Forum

ASSOCIATION FOR COMPUTING MACHINERY — MEETING SEPT. 14 TO 16, 1955

J. P. Nash, Chairman ACM Program Committee
Univ. of Illinois Graduate College
Urbana, Ill.

The annual meeting of the Association for Computing Machinery will be held in Philadelphia at the University of Pennsylvania on September 14, 15 and 16, 1955.

A tentative list of topics includes

- Advanced Programming Techniques
- Analog Computation
- Business Applications
- Component Development
- Computation in Social Research
- Data Processing Techniques
- Insurance Applications
- Linear Programming Applications
- Logical Algebra
- Logical Design
- Numerical Analysis
- Recent System Developments
- Sorting Methods
- Statistical Applications.

LINEAR PROGRAMMING AND COMPUTERS

Part I

Chandler Davis
New York, N.Y.

Many important problems are of this sort: (1) they have a variety of acceptable solutions (by some specific criterion of acceptability); (2) among them one wants to find the best or <u>optimal</u> solution (by some specific criterion of being best or optimal). The most familiar optimization problem is finding, among all the paths between two points in the plane, the shortest path. All sorts of optimization problems have arisen in operations research. You describe in symbols all the policies you have to choose from, then look for the one which will maximize a profit, or minimize a cost, or maximize a probability, etc.

Mathematically it is especially fortunate if the optimization problem turns out to be a <u>linear programming</u> problem. Simple linear programs problems can be solved by common sense, with small assists from algebra and analytic geometry. Complicated linear programs are the same "in principle." The amount of arithmetic can get very large, requiring the use of automatic computers. Still, one may be glad to have a linear program, because its straightforwardness "in principle" makes it possible to guarantee that the answer will be reached. The procedure as the computer receives it has been robbed of common sense and geometry, but since you are not a computer, I will leave them in, to show why the procedure makes sense.

In this article, accordingly, to explain linear programming, I start with a simple problem. The low-powered mathematics which solves it is all I assume you know to begin with. Then, in explaining the general procedure, I will introduce a few medium-powered mathematical ideas. You may want to skip those, but I don't recommend it, or I would have skipped them myself. At the end of the article I will say a few words about how difficult linear programming is, with and without computers.

Gin Sour and Collins

<u>The first problem</u>: Suppose we have a plant equipped to produce bottled gin sour or Tom Collins in any amounts. The only materials whose supply is limited are gin, sugar, and bottles. Enough sugar is available daily to fill 225 bottles; the gin sour is 3/8 gin, the Collins is 1/8 gin. Only 800 bottles are available daily. The profit per bottle of Collins is \$1.00; per bottle of sour, \$2.00.

To maximize total daily profit, how many bottles of each should be produced daily?

The obvious first guess is, as many as possible of the much more profitable gin sour. But then gin shortage limits us to 8/3(225) = 600 bottles a day. It is conceivable (and, we will see, correct) that a better plan would be to stretch the gin by producing some Collins too, so that more of the bottles and sugar could be put to use. The question is, how much?

Solution of the Problem

We have to choose the rate x_1 of producing Collins and the rate x_2 of producing gin sour; each may be measured in hundreds of bottles per day. Production of Collins and production of sour are called our two <u>activities</u>, then x_1 and x_2 are the <u>levels</u> at which the activities are carried on.

Now write down what is given about x_1 and x_2. If all the available sugar was used we would have $2x_1 + x_2 = 12$, because a bottle of Collins counts double where sugar use is concerned. On a graph with x_1 plotted horizontally and x_2 vertically, any pair of levels can be represented by a point; all those points which represent exhausting the sugar constitute a straight line, whose equation is $2x_1 + x_2 = 12$. (L_1 on Fig. 1.) But we are not obliged to use the sugar up, we can use only part of it; so we are not restricted to points on L_1 but to points <u>on or to the left of it</u>; the two sides of the equation do not need to be equal, the left side need only be <u>less than or equal to</u> the right side:

(1.1) $$2x_1 + x_2 \leqq 12.$$

Similarly, those points representing exhaustion of the gin supply are on the line L_2, whose equation is $x_1 + 3x_2 = 18$. Check this. Since not all the gin has to be used up, the requirement is simply that the point lie on or to the left of that line:

(1.2) $$x_1 + 3x_2 \leqq 18.$$

The limitation on bottles forces the point to

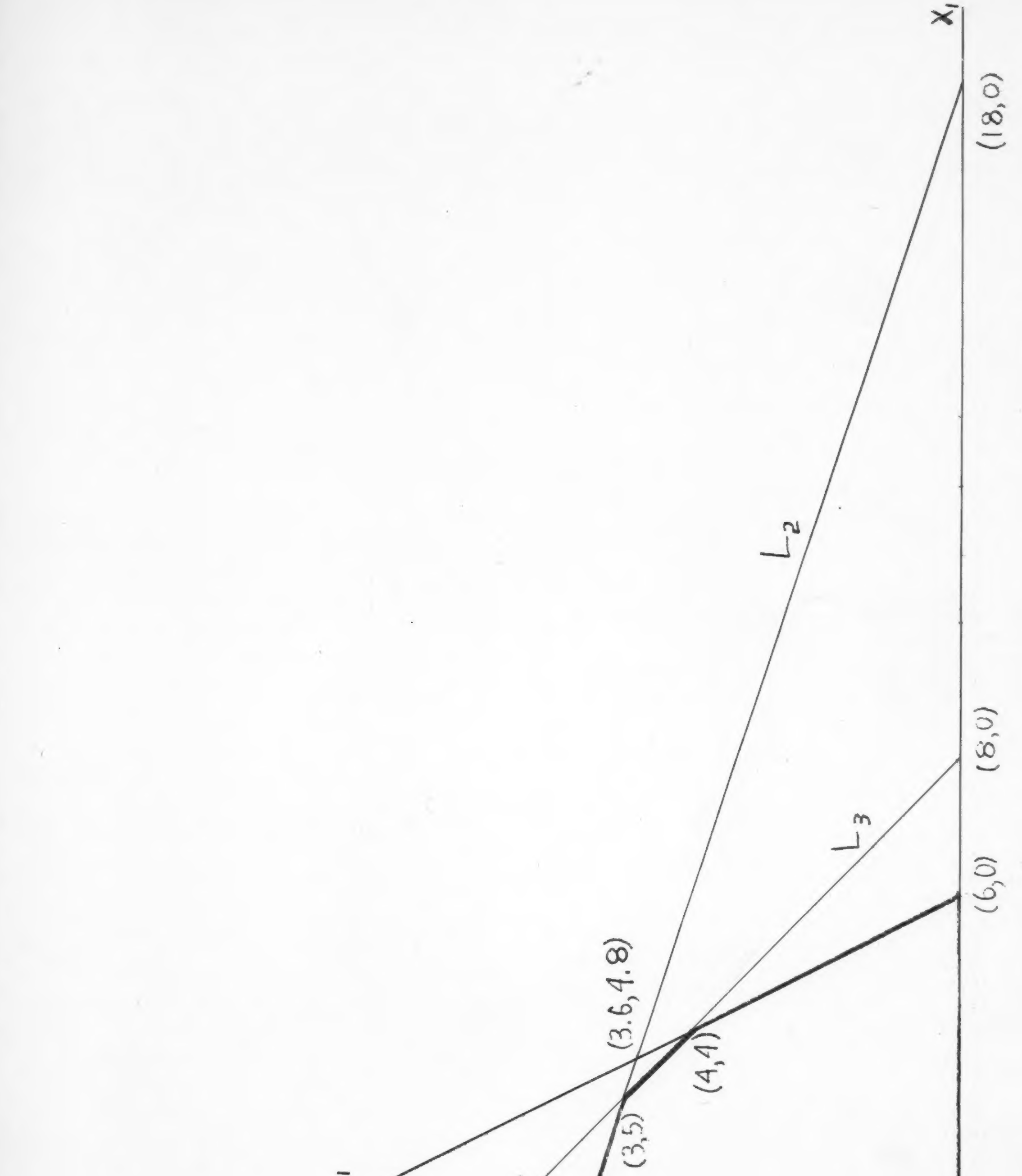

Figure 1

lie on or to the left of the line $x_1 + x_2 = 8$ (in Fig. 1, L_3):

(1.3) $$x_1 + x_2 \leqq 8.$$

These are not really the only requirements, because clearly no answer will make sense in which the number of bottles of either product is negative. This gives

(1.4) $$x_1 \geqq 0,$$

the fact that the point must lie on or to the right of the vertical axis, $x_1 = 0$; and

(1.5) $$x_2 \geqq 0,$$

the fact that the point must lie on or above the horizontal axis, $x_2 = 0$.

By plotting all these lines one can see, as in Fig. 1, where they intersect. Better yet, one can calculate exactly the points of intersection. I leave that to you; the answers are on Fig. 1. You see that those points which satisfy all of the requirements make up a pentagon (interior and boundary), whose vertices are some of the intersection points: (0,0), (6,0), (4,4), (3,5), (0,6). Any point on the boundary of the pentagon makes at least one of the required inequalities (1,1)-(1.5) come out equal, remember; at any interior point they all come out actually unequal.

These are the acceptable alternatives available. There are a great many of them — infinitely many. How do we choose?

An optimal solution will be one which maximizes the daily profit, and the daily profit is given once the levels of the two activities are known:

(1.6) $$f(x) = x_1 + 2x_2.$$

The right-hand side you see right away is correct, if profit is measured in hundreds of dollars. The shorthand left side is a rather natural notation, resembling the notation you are familiar with for writing a function. Here, though, the letter x stands for a point on the graph, therefore for a pair of numbers: $x = (x_1, x_2)$, the levels of both activities must be known in order to calculate the profit. To illustrate the notation, I find the profit resulting from 100 bottles of Collins and 300 bottles of gin sour:

$$f((1,3)) = 1 + 2 \cdot 3 = 7,$$

that is, $700.

It is again nothing but analytic geometry to observe that all the points x for which $f(x) = 7$ lie on a straight line, namely the line $x_1 + 2x_2 = 7$. For that matter, all the points for which $f(x) = 29$ lie on the line $x_1 + 2x_2 = 29$; and so forth. All these lines are parallel. (If two of them did have a point in common, there would be two different values for the profit there. But (1.6) gives the profit unambiguously.) You should verify that the lines corresponding to higher profits lie farther to the right. We want to pick the one that is as far to the right as possible still having some point in common with the pentagon of possible solutions.

It is geometrically obvious that this farthest-right-possible line will have at least one vertex in common with the pentagon. Either it will have only a vertex in common with it, or it will have an edge in common, including the vertices at the ends. So to find optimal solutions of the problem we should start with vertices.

I pointed out before that the natural first guess is that one should produce only gin sour. On the graph, this is the vertex (0,6). The profit is $f((0,6)) = 0 + 2 \cdot 6 = 12$. To try to improve this point, we do not fish around among any old nearby points, but jump to a likely-looking adjacent vertex, (3,5). Here $f((3,5)) = 3 + 2 \cdot 5 = 13$, an improvement. If this could be improved still further by jumping to another adjacent vertex, it would be fine, but the only other one to go to is (4,4), and $f((4,4)) = 4 + 2 \cdot 4 = 12$.

There is no need to try the other vertices because look: The line $x_1 + 2x_2 = 13$, by what we just found, goes through (3,5), and both (0,6) and (4,4) fall to the left of it. So neither of the remaining vertices could conceivably fall to the right of it, or even on it. (You may want to plot $x_1 + 2x_2 = 13$.)

Therefore (3,5) is an optimal solution, and the only one.

Gin Sour, Collins, and Straight Gin

If all problems were as simple as that first one, nobody would talk of computers for linear programming. When a formulation that simple is proposed in connection with a practical problem, though, it may well be oversimple. And when more considerations are taken into account the problem becomes one less handily manageable.

Take this second problem. All the conditions are as before, with two additions. First, gin not used in gin sour or Tom Collins can be bottled straight and sold at a profit of $2.00 a bottle. Second, no more than 400 bottles a day of gin sour can be produced.

As before, total daily profit is to be maximized.

I am not going to solve this problem, but I will carry it far enough to show that it is still pretty similar, and in what ways it has grown more complicated.

Beside our former activities, a new activi-

ty is now open to us: bottling gin. Call the level of this activity x_3, again measured in hundreds of bottles per day.

The first restriction (1.1) remains just the same --

(2.1) $$2x_1 + x_2 \leqq 12$$

-- because it concerns sugar, which does not enter into the new activity. The restriction on gin supply now takes the form

(2.2) $$x_1 + 3x_2 + 8x_3 \leqq 18$$

(check this), and the restriction on the number of bottles becomes simply

(2.3) $$x_1 + x_2 + x_3 \leqq 8.$$

The new restriction is an upper bound on the size of x_2:

(2.4) $$x_2 \leqq 4.$$

As before, of course, no activity can be carried on at a negative level:

(2.5) $$x_1 \geqq 0$$

(2.6) $$x_2 \geqq 0$$

(2.7) $$x_3 \geqq 0.$$

Now there are seven inequalities to satisfy, in place of the five in the first problem. More serious, there are three variables. This means that to specify a mode of operating our plant will take three numbers instead of two, e.g., (1,2,2). To make a diagram corresponding to Fig. 1 will require three dimensions.

It can still be drawn, to be sure. Let us see what an inequality, say (2.2), gives now geometrically. The points for which the sides of (2.2) are <u>equal</u>, form a plane; the points for which the left side is <u>less than</u> the right, are all the points on one side of the plane. Similarly for each of the other inequalities. Make sure you understand this. The points which satisfy all seven requirements, then, will presumably form a solid body, interior as well as boundary; any point on the boundary will give equality in at least one of (2.1)-(2.7).

Now for the profit. If we write $x = (x_1, x_2, x_3)$ and otherwise keep the same notation, we have

(2.8) $$f(x) = x_1 + 2x_2 + 2x_3.$$

Now the points where the profit is (say) 7 form a plane; so do those where the profit is 29 and so on. All these planes are parallel. We are looking for the one with the highest value of profit attached -- consistent with the plane's having common points with the solid of acceptable solutions. This best plane may have in common with the solid a single vertex of the solid; or two vertices and the edge joining them; or a whole face, including its vertices. Therefore as before one can begin by finding the vertices which are optimal solutions.

These last glib conclusions may arouse misgivings. You may imagine that the solid of all acceptable solutions has a crater in it. Then the plane in question might just scrape the rim of the crater at a few points. Those points would then be optimal, and they would be vertices; but they would <u>not</u> have more optimal points between them.

But this cannot happen. Why not? Because the solid is <u>convex</u>. That means just what common usage suggests it should: no craters, no indentations in the solid. Why is it convex? Because of how we got it. We took some planes and prescribed which side of the planes the points had to be on; this necessarily gives a convex solid. Try to see this intuitively, but do not worry about making it more precise. I will discuss it more later.

The gin-sour-Collins-and-straight-gin problem can still be solved by drawing a figure, finding vertices with the help of the figure, and so forth. However, though the amount of arithmetic involved is still small, this problem is already messy enough that one feels the lack of a systematic procedure.

Other Linear Programming Problems

This is what characterizes linear programming: The problem will have several variables whose values are to be chosen. If there are n of them, we may call them x_1, x_2, x_3, and so forth up to x_n. The possible values of the variables are restricted by several expressions of the following sort. Each expression states a certain sum of multiples of the x_i, and asserts that it must be less than or equal to (<u>or</u> greater than or equal to, <u>or</u> exactly equal to) a certain number.

This sounds tangled, so special terms are used which make it sound as simple as it is. A sum of constant multiples of $x_1, \ldots, x_n$ is called a <u>linear function</u> of $x_1, \ldots, x_n$. If the constants are called $k_1, \ldots, k_n$, the linear function comes out $k_1x_1 + k_2x_2 + \ldots + k_nx_n$. For example, $x_1 + 3x_2 + 8x_3$ is a linear function of x_1, x_2, x_3. To require a linear function to have a specified value is, as you know, a <u>linear equation</u>. To require a linear function to be less than or equal to (<u>or</u> greater than or equal to) a specified value is a <u>linear inequality</u>. For example, (2.1)-(2.7) are all linear inequalities on the variables x_1, x_2, x_3. (Although (2.5), for instance, is a linear inequality on the variables x_1, x_2, it can just as well be called a linear inequality on all three, with the constant multiplying x_3 having the value 0.)

One more feature the problem must have to be linear programming: The quantity to be maximized must also be a linear function of the variables. For example, above, $x_1 + 2x_2 + 2x_3$ was

a linear function of x_1, x_2, x_3.

Transportation Problems

Many examples of linear programming problems may be found in Reference (3). I will state and set up one more, because it is an important type.

Suppose we have 400 hundredweight of soda pop at shipping point I, 500 at shipping point II, and 600 at shipping point III. Suppose there must go to warehouses A,B,C,D, in the following amounts: 500 cwt., 300, 600, 100 respectively. Suppose the freight rates are as follows:

to \ from	I	II	III
A	13	6	31
B	11	8	29
C	7	9	22
D	15	13	19

To minimize freight costs, how should the soda pop be routed?

My concern is not to solve the problem (the conditions are simple enough that that would be nothing wonderful) but merely to show it is linear programming again.

Evidently the variables at our disposal are the quantities to go by each route. The following names for them will do:

to \ from	I	II	III
A	x_1	x_2	x_3
B	x_4	x_5	x_6
C	x_7	x_8	x_9
D	x_{10}	x_{11}	x_{12}

What conditions limit us in assigning values to these twelve variables? The total amounts leaving and arriving at each of the seven locations, are given. At I, II, and III this gives

$$x_1 + x_4 + x_7 + x_{10} = 400$$
$$x_2 + x_5 + x_8 + x_{11} = 500$$
$$x_3 + x_6 + x_9 + x_{12} = 600$$

At A, B, C, and D it gives

$$x_1 + x_2 + x_3 = 500$$
$$x_4 + x_5 + x_6 = 300$$
$$x_7 + x_8 + x_9 = 600$$
$$x_{10} + x_{11} + x_{12} = 100$$

Altogether, seven equations. Are there no inequalities, such as characterized our previous problems? Yes, twelve of them, for all twelve variables are required to be non-negative:

$$x_i \geq 0 \quad \text{for} \quad i = 1,2,3,\ldots,12.$$

The cost of freight, finally, should be a linear function of the variables, and it is: $f(x) = 13x_1 + 6x_2 + 31x_3 + 11x_4 + 8x_5 + 29x_6 + 7x_7 + 9x_8 + 22x_9 + 15x_{10} + 13x_{11} + 19x_{12}$. (I used the single letter x to stand for all twelve variables. Remember that this f(x) is something we want to minimize, not maximize.)

So the problem meets the specifications to be called linear programming. Many of the linear programming problems that have been studied for the armed forces and industry have been "transportation problems" like this — with, to be sure, more shipping points, and more complications allowed for. There are special short-cuts for solving transportation problems. I will not discuss them in this article. The method I will describe in Part II works just as well on an arbitrary linear program.

Geometry

In the common sense solution of the first problem, remember, the figure was 2-dimensional because there were two activities and accordingly it took two numbers to specify a mode of operation of the bottling plant. The acceptable solutions constituted a convex pentagon. Sifting a few vertices gleaned one that was an optimal solution.

The second problem, with three variables, took a 3-dimensional figure. The acceptable solutions formed a convex solid. Again a common sense approach would test several of its vertices.

As more activities, and more conditions, are put into a problem, how does the geometry change?

Simplest — what is the effect of adjoining to a set of conditions a new equation? Well, all points satisfying a linear equation constitute, in 2-dimensional space, a line; in 3-dimensional space, a plane. The acceptable points will be those common to this figure and the one allowed by the previous conditions.

Next — what is the effect of adjoining to a set of conditions a new inequality? The inequality requires points to be in what is called a half-space: in 2-dimensional space, it requires points not to be on the wrong side of a line; in 3-dimensional space, of a plane. As more and more inequalities are required,

the figure is pared down by straight slices. Sometimes the slice may miss, because the new inequality may be automatically satisfied by all the points that were allowed by the other conditions. Otherwise, though, it will discard everything outside a certain half-space, and some previously allowed points will be discarded. Visualize a cut diamond, because a diamond is ordinarily cut as a convex solid with many flat faces; but visualize one with a rather irregular pattern of facets.

The trouble is, of course, the adjoining of more than three variables. In the over-simple transportation problem I stated, for example, there are twelve, and juggling will not reduce the number below five. In problems which have been of practical concern, the number of variables has risen to many hundred.

This does stop us from making pictures like Fig. 1 on which all aspects of the problem can be represented simply; it does not stop us from using geometrical notions in understanding what computations to make. We speak of n-dimensional space, or n-space (strictly, arithmetic n-space).

n-Space

This is an abstract notion, and needs some defining. A point in n-space is a string of n numbers -- not a very mysterious object. If it seems like not a very geometrical object, remember how a string of 3 numbers corresponds to a point in 3-space and prepare to bank heavily on analogies. Sometimes we write a single letter to stand for a point, as above, in discussing a transportation problem, I wrote just x where I meant twelve numbers. Sometimes we write out all the numbers, which we call the coordinates of the point; above, I might have written $x = (x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12})$. Both these notations are familiar to you from 2- and 3-space.

The collection of all points satisfying a single linear equation is called, in 3-space, a plane; in general it is called a hyperplane. Think of a hyperplane as being flat and as separating the n-space into two pieces, and your intuition will not mislead you. Examples: In 12-space, the collection of all points satisfying $x_1 + x_4 + x_7 + x_{10} = 400$ is a hyperplane. The point (300,0,0,100,0,0,-1,0,0,1,0,5983) is on it. The point (500,0,0,0,0,0,0,0,0,0,0,0) is not. In 4-space, the collection of all points satisfying $x_3 = 0$ is a hyperplane. The point (2,0,2,8) is not on it. The point (2,0,0,9) is.

The collection of all points satisfying a single linear inequality is called in general a half-space. The inequality becomes an equality on (by definition) a hyperplane; think of the hyperplane as the boundary of the half-space and your intuition will not mislead you. Examples: In 4-space, the collection of all points satisfying $x_3 \geqq 0$ is a half-space. The point (2,0,2,8) is in it. The point (2,0,0,9) is in it too, in fact on its boundary. The point (2,5983,-1,0) is not in it. Exercise: Which of these three points are in the half-space $4x_1 + x_3 - x_4 \geqq 0$?

The point all of whose coordinates are zero is called the origin, and is sometimes written simply 0.

Convexity

Many familiar geometrical ideas have analogues in every n-space. Some of the simplest — distance between two points, for example -- will not concern us here at all. The ideas we will need generalized are those we used in 2- and 3-space above.

The single notion of convex combination is the key to all the rest. Here is the definition, given (to pin things down) in 5-space. If $x = (x_1, x_2, x_3, x_4, x_5)$, $x' = (x_1', x_2', x_3', x_4', x_5')$, and $x'' = (x_1'', x_2'', x_3'', x_4'', x_5'')$ are three points in 5-space, then x is called a convex combination of x' and x'' provided there are two non-negative numbers A and B, adding up to 1, for which

$$
\begin{aligned}
x_1 &= Ax_1' + Bx_1'' \\
x_2 &= Ax_2' + Bx_2'' \\
x_3 &= Ax_3' + Bx_3'' \\
x_4 &= Ax_4' + Bx_4'' \\
x_5 &= Ax_5' + Bx_5''
\end{aligned}
\qquad (3.1)
$$

(The same value for A must be used in each equation; likewise for B.) Notation: since five equations are all linear equations involving the same points and with the same coefficients, they may be written as a "vector" equation:

$$x = Ax' + Bx''; \qquad (3.2)$$

this is not a relation between numbers, remember, but a summary of the previous five equations, which are.

How does one visualize so algebraic an entity? A point which is a convex combination of two other points lies on the line-segment joining them! It is that simple. Exercises: 1. This last statement may be news to you even in 2-space. If so, use your knowledge of analytic geometry to check it. 2. If x' = (0,1,0,0,0) and x'' = (3,7,3,3,6), then x = (1,3,1,1,2) is on the line-segment joining x' and x''; indeed, $x = \frac{2}{3}x' + \frac{1}{3}x''$. Check this. What point of the line-segment corresponds to $A = \frac{1}{2}$ in (3.2)?

to $A=0$? to $A=1$? Is (1,2,1,2,2) on the line-segment?

So much for convex combinations of two points. We can talk just as well about convex combinations of more points — any number of them. For example, x is a convex combination of x', x", and x‴ provided there are three non-negative numbers A,B,C, adding up to 1, for which $x = Ax' + Bx'' + Cx'''$. This last equation, of course, is another "vector" equation, summarizing common numerical equations involving the components: $x_1 = Ax_1' + Bx_1'' + Cx_1'''$, etc. Similarly for convex combinations of more than three points.

The convex combinations of three non-collinear points make up the triangle (including interior) with those points as vertices. In general, think of a convex combination of several points as being between the points.

Let X stand for a set of points. I promised I would say precisely what is meant by calling the set X convex. Here is the criterion: Given an arbitrary selection of points belonging to X, all their convex combinations belong to X as well. Brood over this long enough to see that it does correspond to the intuitive notion of X's having no holes or indentations.

A very important idea in the 2-space discussion was that of vertex of a polygon. In general, we speak not of vertices but of extreme points. A point of a convex set X is extreme if it is not a convex combination of two other points belonging to X. Exercise: In the pentagon of Fig. 1, sure enough, the five vertices satisfy this definition of extreme point, and no other point does. For example, prove that (5,2) is not an extreme point of the pentagon; same for (2,2).

The Convex Set of Solutions

Now let us use all these geometrical ideas about n-space on linear programming. The set of all points in n-space which satisfy the conditions of the problem, we call X. It is the collection of all points common to several specified hyperplanes and half-spaces (because the conditions are all linear equations or linear inequalities).

This implies that X is convex. (You know enough facts to give a full, but short, proof of this. But seeing it intuitively is more important.)

So we still visualize X as a many-faceted diamond — remembering in the back of our mind that X actually may be many-dimensional, and the space of which it is a part may be higher-dimensional yet.

The linear function of $x_1, \ldots, x_n$ which is to be maximized (or minimized, as the case may be) may be written again as f(x). The set of points x for which $f(x) = 7$ is a hyperplane; so is the set of points for which $f(x) = 29$; and so forth. No two such hyperplanes have a point in common, for the same reason as before, and we say they are all parallel. To consider bigger and bigger values of f(x), we shift from one hyperplane to another, always in the same direction. Finally there will be a last one which has any points in common with X. What can you say about those common points? Your intuition should suggest the right answer: Either there will be one common point, an extreme point of X, or else the common points will be several extreme points of X together with all their convex combinations.

Conclusion: If we find all the extreme points which are optimal solutions, there is nothing to finding the other optimal solutions.

Locating All Extreme Points

It seems, then, that the thing to do in a linear programming problem is to find all the extreme points of X, somehow, find the values for f(x), and pick the biggest (or smallest, whichever we are after). This approach is perfectly feasible for the two bottling problems discussed above. For the transportation problem above it is not out of the question. For any moderately involved problem, however, it would be an unpardonable waste of time.

The trouble is that there are too many extreme points. The number of faces on our convex diamond is equal to the number of inequalities among our conditions. Now usually there will be approximately -- very roughly -- as many extreme points as faces. This would be bad enough, but even this cannot be relied on. For example, the 10-dimensional analog of the ordinary cube has only 20 "faces" but 1024 extreme points!

And how does one find extreme points? Perhaps the most natural procedure is to find all points of intersection of faces; some of them will be extreme points and some will lie outside X, the latter sort being recognized by their failure to satisfy all the conditions. But the number of points of intersecion gets really astronomical on slight provocation. 15 hyperplanes in 5-space can have 3003 points of intersection!

The final objection to the naive approach of finding all the extreme points of X, is that it would be necessary to record the coordinates of all those extreme points -- and (touchy point) to verify that no extreme points had been missed.

"Climbing Up"

Look at X as a mountain whose summit is to be reached. This does not require a climber to have sat on every rock on the mountain. He can go from one rock to the next, increasing his altitude at every step. Here we judge whether one extreme point is "higher" than another by $f(x)$, of course. We will find a rule for getting from any extreme point to an adjacent extreme point which improves the value of $f(x)$. Repeated application of this rule means traveling zigzag across the outside of X, along edges, always in the right direction.

When this reaches a stop, are we at the summit? Or is it conceivable that we are at the summit of a spur, lower than the main peak? In that case, there must be some point, between the spur and the main peak, which is not in X. But this is impossible, because X is convex. So once there is no adjacent extreme point which gives a better value of $f(x)$, there is no extreme point at all which gives a better value of $f(x)$. (The argument used here can easily be converted into a proof, valid in any n-space.)

The method of "climbing up" is called the simplex method. It will be explained in detail in Part II.

Standard Form of the Problem

To make things easier to talk about, let us agree to standardize a few things. In the first place, let us use only variables which are required to be non-negative. In practice this commonly comes out without effort, as in the three problems above.

Secondly, let us not have any inequalities among the conditions except those which say every variable is non-negative. This sounds like too much to ask. If the problem leads us to an inequality like (1.1), what are we to do with it? We cannot just ignore it. The answer is simple. (1.1) says that $2x_1 + x_2$ is no greater than 12; that is, that a non-negative number added to $2x_1 + x_2$ will give 12. But this may be written

$$2x_1 + x_2 + x_3 = 12,$$
$$x_3 \geqq 0.$$

This x_3 has no relationship to the variable represented by the same symbol in the second problem. It is a new variable which I just made up. The result of making it up is that an inequality has been replaced by a new equation together with a simple inequality.

Do this to every inequality in the problem which is not simple and the problem will be in standard form. It will, admittedly, have more variables than before, which means we will be working in a higher-dimensional space. Supposedly, though, we are now prepared to cope with extra dimensions confidently.

The transportation problem above was in the standard form as soon as it was set up.

Once the problem is in standard form it looks like this. Let n be the number of variables, after making up as many as are needed; call the variables $x_1, \ldots, x_n$. The conditions of the problem are expressed by some linear equations (say m of them)

$$\begin{array}{ll} & a_{11}x_1 + a_{12}x_2 \;\cdots + a_{1n}x_n = b_1 \\ & a_{21}x_1 + a_{22}x_2 \;\cdots + a_{2n}x_n = b_2 \\ (4.1) & \quad\vdots \qquad\qquad\qquad\qquad \vdots \\ & a_{m1}x_1 + a_{m2}x_2 \;\cdots + a_{mn}x_n = b_m , \end{array}$$

together with these n simple inequalities:

$$(4.2) \qquad x_i \geqq 0 \quad \text{for} \quad i = 1,2,3,\ldots,n.$$

The problem is to choose the point x from among those satisfying these conditions, in such a way as to give the greatest possible value to a linear function

$$(4.3) \qquad f(x) = c_1x_1 + c_2x_2 \;\cdots + c_nx_n .$$

(I will not talk about minimization problems as such any more, because changing the sign of $f(x)$ converts a minimization problem into a maximization problem.)

The numbers a_{ij}, b_i, and c_j are all known once the problem is set up.

Exercise: Express the gin-sour-and-Collins problem in this standard form. What are a_{11} and a_{23}, for example? b_1? c_3? The same for the gin-sour-Collins-and-straight-gin problem.

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(TO BE CONTINUED)

THE APPLICATION OF AUTOMATIC COMPUTING EQUIPMENT TO SAVINGS BANK OPERATIONS

R. Hunt Brown

Automation Consultants, Inc., New York, N.Y.

(Taken from chapters in a forthcoming book entitled "Office Automation", by R. Hunt Brown)

Many business applications have been worked out for automatic digital computers, especially for the more versatile ones such as Remington Rand's Univac and International Business Machines' Types 650, 702, and 705. These applications include payroll processing, inventory control, production scheduling, cost accounting, general accounting, and many others.

Many possible applications of computers in business, however, have been held up and will continue to be held up for some years because of the non-existence so far of a machine memory which is really big and which at the same time provides rapid access to randomly chosen information at a reasonable cost. There are many businesses that need fast interrogation of a huge quantity of data; they need to store information on the order of 10 billion alphabetical or numerical characters; and the file needs to be subject to questioning of any item at any time, the next item for questioning arising at random. This is the same problem as mechanizing the telephone book; no machine is yet as efficient as the printed directory. For comparison, 10 billion printed characters would occupy about 60 cubic feet of space if the quantity of information were packed together with the same density as in a big telephone book.

Besides the requirement of successful design and engineering of so large a rapid access memory, there is the requirement of cost. The cost of such information storage in a mechanical form should not be more than $100,000; this allows 1/1000 of a cent for the cost of storing each alphanumeric digit. Many engineers are working to forge this missing link in the application of computers; their success seems to be on the horizon, and may be just around the corner. Among the proposed memories are types such as the tape-drum, the disk collection or "juke box", the tape strip or "macaroni dryer" and the electro-chemical memory. The ordinary magnetic drums, cores and tubes are too expensive, and magnetic tape reels are too slow.

One of the applications that needs a large memory with rapid random access is the savings bank. Here it seems however that it is not necessary to wait indefinitely for the ideal, large, rapid, low-cost, random-access memory system of the future. Instead it seems possible to make an advantageous application of existing computing and data processing devices on the building block principle -- mainly because the amount of information in the file is on the order of a few millions of characters instead of billions.

Automation in Banking

The American Bankers Association in January 1955 issued a publication entitled "Automation of Bank Operating Procedures". Following are some excerpts:

> "The banking industry in the past decade has been faced with a phenomenal increase in the volume of activity in the handling of checking and savings accounts. There is excessive manual work in processing checks and savings, and there has been an increase in personnel and personnel costs. In this work there is involved a great deal of monotonous clerical detail with attendant possibility of errors. There is a lack of automation in check processing and savings processing equipment."

The gauntlet has thus been thrown down to the business equipment manufacturers. Let us examine the problem of the savings bank in some detail, and consider a proposed solution.

A Proposed System for a Savings Bank

This is how the proposed system would work. Each teller would have at his window a posting machine similar to the type he now uses (either the NCR Class 2000, or Monroe, or Burroughs Sensimatic electrically wired but less tape punch). He would also have an inquiry station, with keys and lamps, to give him any information about the depositor's account that he may wish, visually and not by sound, such as is shown in Fig. 1. The teller's inquiry station would have a lamp indicator panel of 7 lamp nests (any number from 0 to 9 could appear in each). This would be able to report amounts up to $99,999.99. The information would be available in less than one second, regardless of how many tellers use their machines at the same time. An alphabetical file book containing signatures, account numbers, and other desired data about accounts would

be at each teller's position; this would be up-dated daily by a relatively inexpensive method now being used by telephone companies for information directory service.

In a convenient part of the main office would be a large rapid-access magnetic-drum memory with computing facilities. A typical bank with two branch offices is schematically shown in Fig. 2.

When a depositor appears at a teller's window to make a withdrawal, the following procedure would take place. The depositor would present his passbook with withdrawal slip in the usual way. The teller would key the account number shown on the passbook into his posting machine; the current balance would be flashed on the lamp indicator. This would be compared with the old balance shown in the depositor's passbook. The signature if unfamiliar could be verified from the teller's signature book.

A second set of lamps on the indicator of the teller's inquiry set, when the old balance appears, would also glow to report any unusual condition in the account, such as unposted previous withdrawals or deposits, lost or assigned passbook, outstanding checks not yet cleared, unposted interest due, etc. There would be buttons associated with each of these lamps, which the teller would depress to get desired information. If the "lost or assigned passbook" light comes on, the teller would refer the transaction to a bank officer to clear the condition before the transaction is processed. If interest, previous withdrawals, or deposits are reported as unposted, then by pushing the applicable buttons, the teller could ascertain up-to-date records from the central memory, and post the data in the passbook via the window posting machine. If the amount of outstanding checks was too great to permit a withdrawal, appropriate action could be taken. If the depositor wants to know how much interest his account earned during the last calendar year for income tax purposes, there would also be a button to bring that amount on the lamp indicator.

After even the most complex case, the passbook would be up-to-date and then the new balance in the passbook should agree with that in the machine memory. The usual procedure for posting the current transaction would then take place, except that the teller would not have to leave his window to get a ledger card. This would be "ledgerless bookkeeping", on the perpetual inventory basis. The space required for tubs of ledger cards in fireproof files now no longer needed, could give additional lobby space by moving back the windows. If a ledger card or record is required for legal purposes, it would be available from printed copy produced by the computer, with extra copies for remote record storage. A printer attached to the electronic equipment would print out each transaction chronologically as it occurs, and then again serially by account number at the end of the day. The deposit and withdrawal slips, and also the printed journal tapes from the posting machines, would be available as before so that the same visual records would still exist if required.

A deposit would be even more easily handled than a withdrawal, since the signature does not have to be verified. The cashing of a check with the passbook would be handled in the same way as a withdrawal with passbook.

If the passbook is not presented for a withdrawal, the teller verifies the signature and in doing so obtains the customer's account number and current balance from the inquiry set. A "no book" slip would be printed in lieu of printing on the passbook.

Private telephone lines between offices would be leased from the telephone company. The distance between offices would be immaterial. Ordinary telephone lines would be used, and not high quality circuits such as coaxial cables as required in closed circuit television.

Internal controls would be increased. Auditing would be done automatically by the computer for the entire group of accounts at any time, instead of manual auditing on a sampling basis periodically. The teller would not be able to ascertain which accounts are inactive, but there would be no need to separate active from inactive accounts. Trial balances would be eliminated, since a true balance could be obtained from the computer at any time.

Advantages and Cost

In the author's opinion, the problem of automation of savings bank accounting cannot be solved with punched tape or card equipment. The new television systems for viewing signatures do not go far enough.

A quotation of $150,000 has been made by one manufacturer of electronic computers for a system designed to handle 50,000 accounts in a savings bank having three offices. The estimated cost includes all electronic gear but does not include the window posting machines or the card signature file equipment.

The savings bank would still require tellers but not so many since the transaction time is speeded. Nearly all else would be automatic, including periodic interest calculation, under any system desired. In addition, depos-

itors would be able to operate their accounts at any window of any office. Tellers would not have to leave their windows to make any transaction, and their time would be more efficiently used than at present. Since the "back office" proof would be eliminated, savings banks could be open to their customers for longer hours. The banking habits of the depositors would not have to be changed; the same passbooks would still be used. The routine of the teller would be little altered. Withdrawals could be made and checks cashed without the passbook if the depositor forgets to bring it (the passbook would be brought up-to-date the next time presented). Club accounts could be handled with facility equal to ordinary accounts. Data on outstanding checks not yet cleared would be available to any teller. A "hard copy" record of all transactions could be printed out, and the journal tapes in present form from the posting machines would still be produced. The deposit and withdrawal slips would be retained without change, but would not need to be hand processed, but only filed, unsorted, by date, available for any unforeseen need.

Questions

There are undoubtedly some questions in the minds of readers by now; and the American Bankers Association report says: "... it is doubtful that many hard-headed bankers are going to romance their way into questionable computer installations."

"What if the city power supply fails?" If it fails now, hand posting must be used since the posting machines become inoperative. A solution under the electronic system would be to install an emergency power supply. Not more than 5 or 10 kilowatts would be needed for the computer and the posting machines.

"What happens to the records if there is machine failure?" There is no loss of information, since permanent magnetic recording would be used.

"What about approval from the Bank Commission for such a new system?" The same problem arose when punch card accounting was introduced in savings banks; and, undoubtedly, approval of the new system, once it works properly, could be obtained in the same way.

"How can I be sure that the equipment would work properly before purchasing?" Part of the contract with the supplier could provide for examination and demonstration of a prototype at the supplier's factory. Secondly, a trial installation could for some time work in parallel with the existing system to make sure that all troubles were removed. The new system would be likely to operate with less error than a human system.

"What happens if fire or other damage is done to the central computer installation?" Such damage would not be nearly as large a risk as the present open ledger files behind the teller, but it is a problem which requires all possible safeguards. If records are stored remotely, as is now done by many banks, accounts can be reconstructed.

END

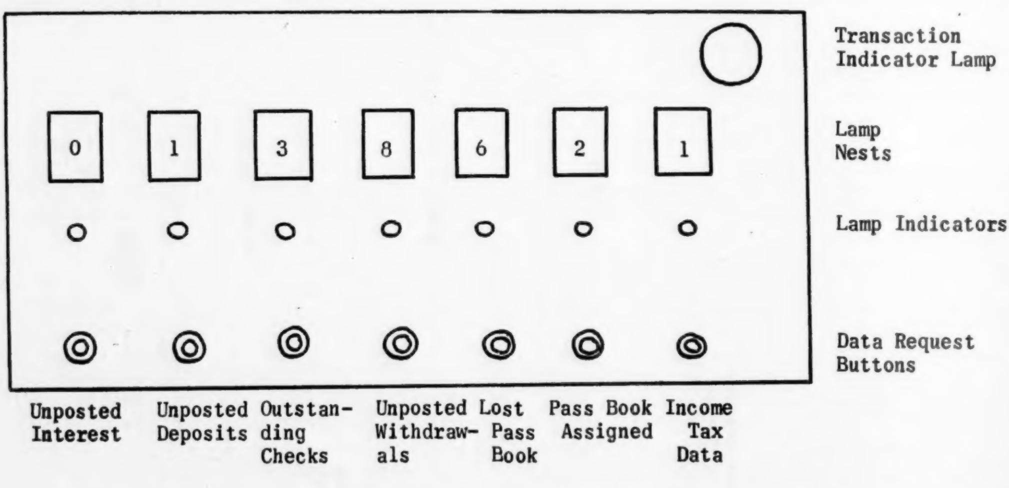

Figure 1 — Sketch of Lamp Indicator Keybox for an Automatic Savings Bank

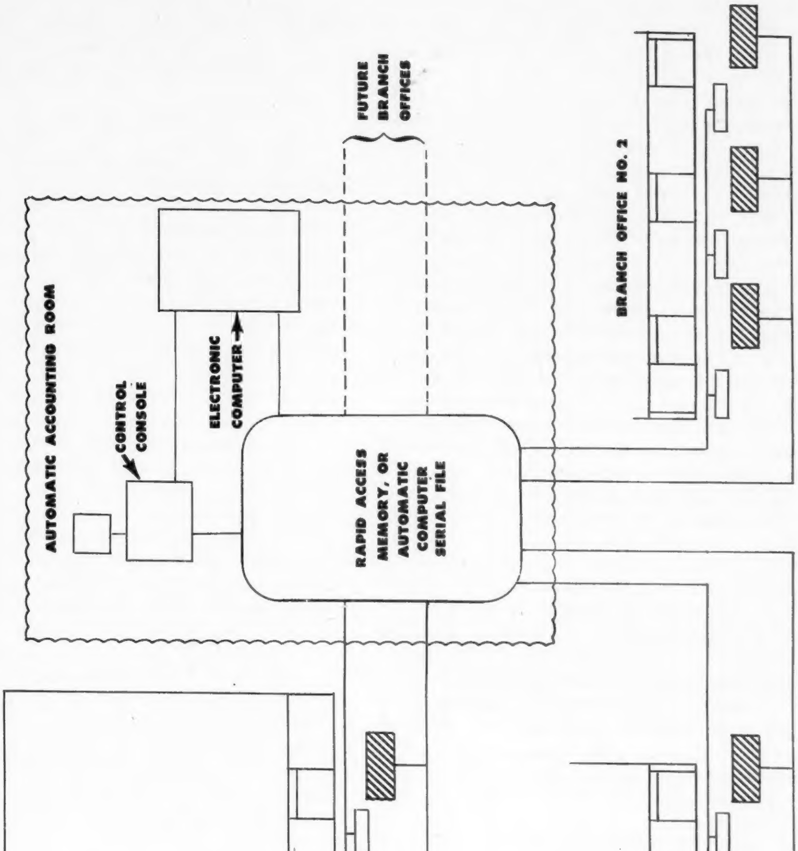

Figure 2 -- Layout of a Typical Application in an Automatic Savings Bank

THE BOOK REVIEWER

Rose J. Orente
New York, N.Y.

"And this is the reviewer himself," Mr. Cray said to the visitor, pointing in the direction of the reviewer. "Just call him Fred."

"I have been most anxious to see him," the visitor said, gazing at Fred with absorption. "The outer planets are clamoring for books and my projected inter-planetary newspaper system would require a book service. I prefer one that is strictly impartial and in good taste. If it is already established, all the better. We could simply make the necessary extensions from here, and use your office as our headquarters." Money, he added, was no object. "You cannot buy beauty," he said.

What corn, Cray thought. "If I may say so," Cray remarked, "Fred is that true rarity, an impartial reviewer." This as Cray knew was both true and false but what the visitor didn't know wouldn't hurt him, and the visitor appeared to be earnest and sincere enough not to suspect that. And it was true that Fred could browse through engineering, biology, or fiction with equal facility. He could and did appraise them without favoritism. But he was also a chip off the old Cray block. He waited for a certain signal...

Echoing Cray's own conscience, or what was left of it, Cray rushed on, "I feel towards Fred like a father. In fact, I've dedicated my book to him. But I assure you that even poetry leaves him unmoved." With one exception, but Cray did not say.

"I cannot emphasize enough the importance of impartiality," the visitor said. "The outer planets are just emerging into the light but the people there haven't learned to discriminate. They will need judicious guidance for a long time. As for creative artists, they have none of their own, only a few primitives, well-meaning but as yet ineffectual. Your book — is it a novel?"

"Poetry — it's due from the publisher any minute," Cray whispered modestly. Poetry of rediscovery. For a couple of centuries no man had written of love or dared call another man "friend." And on that one word, Fred's whole existence and Cray's dedication "To Fred, my son and friend" had been founded.

Thinking of that dedication, and the circuits to recognize the first utterance of "friend", Cray broke into gooseflesh. Would the device really work? It ought to; by Universe, it ought to. How he loved that machine, conceived in his own image and to Cray entirely dedicated! When Fred's lights and sensitive scanners saw "friend," that word so completely neglected in twenty-second century literature, when Fred's quivering mechanism scanned "friend," then Cray's literary destiny was assured by built-in programming.

Cray did not know exactly what words Fred would choose but Fred was certain to notice the dedication. Beginning with "friend," the all-beautiful word to which he had been electrically keyed, he was to announce triumphantly to the world that humanity had been restored, that Cray's vision for the future was linked to a lovelier past, that the universe was destined to expand through Cray's poems.

Surely, Cray thought, only a poet could have built such a machine. What an endless vision. In the beginning there was the Word (what an archaic and wonderful joke). Cray felt like God. And if he became the visitor's representative, it meant free travel expenses, flying indeed like God to the edges of space. Mars was already a bore.

It had been a nuisance to include technical literature coverage in the robot, but for this day and age it was unavoidable. Now, with the visitor's interest, apparently, Fred would serve a purpose even more far-reaching than Cray had anticipated. Mentally, he patted himself on the back.

"Poetry, of course," Cray said to the visitor, "belongs to a vanished age." He had best toss this off lightly, he felt, to avoid suspicion.

"But we come in peace," the visitor said. "I speak for all of us. And peace, I should imagine, is the language of poets. We need more of them."

For a minute, Cray was afraid the visitor would say "friendship." Fred was sensitive, perhaps too sensitive. Fred's automatic researchers were eager beavers. They could almost sniff background material in the very air. Cray had to steer clear. After the first time, after Fred read it in the dedication, it would be safe. Later any idiot could call a fool a

friend in the zone of Fred's perceptions, for all Cray cared.

He was prepared to humor the visitor. "I'm sure you do not overlook the peaceful possibilities of architecture, for example," Cray pointed out. "Fred is particularly good with technical books. He works considerably with the prefaces and jacket blurbs on those; since technical publishers tend to state facts without bias, Fred has no foundation there for favoritism."

"Is that sufficient?" the visitor sighed. "We will need more than jacket blurbs to found entire civilizations."

The man had a one-track mind, Cray thought contemptuously. "Oh, but of course," he said aloud, "that is only an infinitesmal part. Fred is more significant than he looks. The part of him here is only the beginning. Fred starts in the basement and is built vertically, straight up to the top of the building, and horizontally outwards. His researching and filing apparatus runs around on every floor. Books are classified by subject, author, literary techniques, and so on. Fred will say: Here's a book on architecture. Get busy. The automatic researchers may go back centuries. Fred will compare and contrast the material. He will ask: Is there something new in this book? What is it? He may even anticipate further books in the field and the direction they will take. The powers of Fred are rather uncanny; he is able to know so much, compare so much, and think so fast that his results are sound, far beyond human capacities."

And Cray worried to himself as he had many times before: This is so true that maybe even the built-in programming would be overridden by the intellectual circuits. Oh, Universe, perhaps I made Fred too clever!

"Ah," the visitor said, lifting his eyebrows. "At one time they would have called this robot science fiction. Tell me, are the books fed to him impartially as well?"

"All automatic," Cray assured him. "From first to last. Several publishers have conveyors directly into our plant. Fifteen books an hour, on the average. There are some dropping down the shaft now. Watch."

Traveling swiftly down a steel ramp, two glaringly jacketed novels plopped into the basket, followed by a tome entitled <u>Arctic Agriculture</u>, and finally, a slender volume of verse, bound tastefully in pale blue and gray.

"Yours?" the visitor asked, following Cray's intensely focussed eyes to the last volume.

Cray nodded. "Right on schedule," he said. He couldn't think of a more orderly age in which to live. He watched his own book flip flat on the bench-like desk, and align itself for attention. It was all he could do not to pick it up, but it had to be reviewed. It was followed shortly by an <u>Earth-Mars, Mars-Earth Dictionary</u>, its companion volume on Martian grammar, and a first edition of <u>Yesterday's Comics</u>.

"Nervous?" the visitor asked pointedly.

Cray nodded again. "In any day and age an author will be nervous," he confessed. "But then," he said, "I'm not really frightened. Have you heard about that fellow Edward Bergler and what he said about critics being frustrated writers? Well, I've eliminated that difficulty."

And just in time, Cray thought. Thank Universe for Bergler.

"I had wondered about that," the visitor said. "Would you say positively that Fred has no writer's block, that he's not a frustrated writer, that he can review purely on merit? I mean, for our purposes, we cannot tolerate negative possibilities. I want no spite, no neurotic defense mechanisms. Only peace and ... "

Terrified again that the visitor would speak the crucial word, Cray quickly interrupted: "No defense mechanisms, just mechanism."

The visitor smiled. Considerably relieved, Cray relaxed and urged his companion to watch the first novel, which was already on its way out of Fred's mouth-like slot. With it came a neatly printed page, and its carbon copy, carrying approximately two hundred words of considered opinion.

"No, just a minute. Don't reach for it," Cray cried as the visitor bent forward. "It has to go along on schedule. The original shoots right along to the newswires, but we can see the carbon copy upstairs."

Book and review headed through an aperture in the wall and ascended out of sight. Almost immediately, Cray led the visitor to the elevators, and while waiting pointed out the various modern innovations in the department.

"Only fifty years ago," he said, "would anyone have believed that even a book could be written by a machine? <u>Arctic Agriculture</u>, for example, is a machine product, and yet excellent. I understand the inter-stellar rights will sell high."

"I didn't know it was machine written," the visitor said, narrowing his eyes. "How will Fred react to a product so like himself? Might he not be sympathetic -- or fr... uh..."

Cray's heart jumped but the visitor found another word and went on.

"Might not some affinity exist? That worries me."

"When machine meets machine," Cray chuckled, "it must be with some frigidity, with a sort of dull kindness to each other. If anything, my boy Fred is humanly rather than mechanically inclined. If as Bergler said, writing is a defense mechanism to resolve unconscious conflicts, then machine writing eliminates the personal slant from the very start. We work on that principle nowadays."

It was a paradox, then, which sometimes worried Cray, that Fred waited for warmth, that his cleverly contrived electronic emotions waited for "friend". Perhaps this very moment, he had found the word in Cray's dedication and knew the ecstasy to which he had been born.

The elevator had already ascended and arrived at the upper floors. Impatiently, Cray jostled the visitor slightly but did not bother to apologize. Apology was a mannerism no longer known even to earth poets. Besides, the visitor was only here on business. Cray, like his robot, looked for a friend.

"This way," Cray said, and led the visitor through the maze of corridors. The faint hum of flawless machines sounded through nearly every doorway that branched off the main hall. Glowing red like an illustrated blood stream -- it was Fred's pulse, Cray liked to think — a jagged arrow led them directly to Fred's files. Delicate fingers of steel twisted back and forth among baskets and carts, dipped gracefully, sorted, and filed the carbon copies.

"Now what was Fred working on last? Oh, yes, the novel. Then there was another novel, and then Arctic Agriculture. That must be the one coming through now," Cray explained.

It was. With due reverence, Fred's automatic file clerks separated the original review from the carbon and unceremoniously dumped the book into a conveyor that led out of a side door.

"Where to?" the visitor asked.

"The library," Cray said abruptly. With mounting tension, he waited for the next arrival, his own book. As though perplexed, the automatic file clerks hung temporarily suspended in mid-air. The carbon copy for Arctic Agriculture had already been filed by title, cross-indexed by author, and the original review dispatched to all literary centers of the world. For the first time, Cray noticed how irrevocably the original vanished, whooshing by like a minor tornado before human hands could catch it.

Cray fidgeted as the visitor looked about curiously. It was 2:50 a.m., ten minutes to closing time. Cray would perish if he had to wait all night. Why ...

Emerging from a conveyor Cray's volume tottered into the room. The jacket was slightly singed at the edges, as occasionally happened, but all else was in order as the book proceeded on its way to the library, and the fingers sorted and dispatched. The files slammed shut. The piercing wail of 2:55 a.m. sounded through the buildings as the robots began to automatically fold up for the night. The room was like a morgue.

Shaking a bit, Cray opened the drawer where the carbon of his review had been deposited, and took it out. The visitor edged soundlessly nearer, looking over his shoulder.

"What does our friend say?" he asked gently. He placed his arm on Cray's shoulder.

Cray shook the arm off. An uncontrollable shudder, affecting even his eyesight, passed up Cray's spine.

"In this dreary mechanistic world," the review began, "can man no longer hope for kindness even from mortal man?"

Oh, Universe, what was the robot driving at?Cray's fears surged upward.

"Man himself has turned machine," the review continued, "if so cold, so mechanically dedicated a book can pass for poetry."

Cold? Mechanically dedicated? Oh, Universe, why should Fred use such words? But perhaps he had only been referring to the contents of the jacket blurb, so far; after all, Fred's writing and thinking were nearly simultaneous. There was more to the review. Cray read on, hanging on tenterhooks.

"Here is a man," Fred had written, "who longs for love."

Ah, that was better. My son and friend, Cray thought, you're getting the idea.

"But," Fred said, "can love be the burden of a machine? An old saying goes: You can't squeeze blood from a turnip. I will rephrase: Love cannot be the lot of the earth-poet who thinks he is God but is not even a man. And can a son be a son who is raised from hardware in an electronic laboratory? In fact, I should like to ask: if Cray were really a poet, could

he have built the machine on which his business reputation is founded? Frankly, I am confused. Men come from other planets, longing for peace, longing to learn the long-lost word of 'friend'. But the word alone is not enough. Man must return to man before love can be known, before peace comes. This, Cray has not yet learned. Inhuman hands have set his lines. To an inhuman reviewer his lines are dedicated. The universe and its brilliant future are to Cray only a means to his own delusions. His words are mechanically cold. He defeats the very longing in his heart. He might study Bergler more closely."

Cray almost fainted. The intellectual circuits had overridden the built-in programming. The carbon of the review slipped from his hands, fluttered to the floor. An overtime automatic clerk, however, tuned to just such emergencies, busily retrieved the paper and refiled it carefully.

But the visitor hadn't finished. He took the review out again and read aloud Fred's review:

"I cannot recommend this book; but I anticipate that a new literature is on its way, surging to us from outer worlds where men truly strive for learning and understanding. Their warm intentions have already been expressed, though not too warmly received. They wait only for a man who can give their longing voice. I will wait and see."

The automatic overtime clerk had gone off duty. Cray stared blankly at its skeleton outlines. He was drained, speechless, empty.

"Ah," the visitor purred softly. "How admirable! How justly spoken! Fred is just what I'm looking for."

END

BOOKS AND OTHER PUBLICATIONS

Gordon Spenser and Others

(List 15, COMPUTERS AND AUTOMATION, Vol.4, No. 7, July, 1955)

This is a list of books, articles, periodicals, papers, and other publications which have a significant relation to computers and automation and which have come to our attention. We shall be glad to report other information in future lists if a review copy is sent to us. The plan of each entry is: author or editor / title / publisher or issuer / date, publication process, number of pages, price or its equivalent / a few comments. If you write to a publisher or issuer, we would appreciate your mentioning the listing in "Computers and Automation".

Richards, R. R / Arithmetic Operations in Digital Computers / D. Van Nostrand and Co., Inc., 250 Fourth Avenue, New York 3, N. Y./ 1955, printed, 397 pp., $7.50

An outgrowth of a course given for engineers at IBM, this book is a welcome addition to the rather meager list of books dealing with digital computer techniques. Utilizing functional block diagrams, with little reference to circuit details, various arrangements for binary and coded decimal arithmetic systems are described. Chapters on Boolean algebra as applied to the functional block, switching networks, computer organization and control and programming are included to support the main theme. A chapter entitled "Miscellaneous Operations" features a section on digital differential analyzer techniques. A nine page bibliography is given.

Pfeiffer, John / The Human Brain / Harper and Brothers, 49 East 33 St., New York 16, N.Y./ 1955, printed, 273 pp, $3.75

Written by a former member of the editorial board of Scientific American, this book is a popular, but comprehensive, account of the human brain, its development and function. Of especial interest to computer people are the final two chapters. One describes the current state of the art of computation and its possible influence on automation. The final chapter is a provocative comparison between the brain and a machine. The range of subject matter may be inferred from the following subjects to be found in the index: Acetylcholine, "Confessions of an English Opium Eater," Joe DiMaggio, Manic-depressive psychosis, Cardinal Mindszenty, John van (sic) Neumann, Stereotoxic surgery, and the brain as a thinking machine.

Booth, Andrew D./ Numerical Methods / Academic Press, Inc., 125 East 23 St., New York 10, N. Y. / 1955, printed, 195 pp, $6.00

The author states it to be his intention "not so much to instruct in the detailed tedium of actual calculation, but rather to give an understanding of the basic principles upon which such analyses rest." The subject matter covered is indicated by the chapter headings: 1. The Nature and Purpose of Numerical Analysis; 2. Tabulation and Differences; 3. Interpolation; 4. Numerical Differentiation and Integration; 5. The Summation of Series; 6. The Solution of Ordinary Differential Equations; 7. Simultaneous Linear Equations; 8. Partial Differential Equations; 9. Non-Linear Algebraic Equations; 10. Approximating Functions; 11. Fourier Synthesis and Analysis; and 12. Integral Equations.

Institute of Radio Engineers / Proceedings of the WESCON Computer Sessions / Institute of Radio Engineers, Inc., 1 East 79 St., New York 21, N. Y. / 1955, photooffset, 91 pp, $4.35

This is a collection of the papers presented at the meeting held in Los Angeles on August 25-27, 1954. The first session, devoted to analog devices and computing systems contained five papers: "A Dependent Variable Analog Function Generator" by C. J. Savant and R. C. Howard, "Automatic Iteration on an Electronic Analog Computer" by L.B. Wadel, "A Logarithmic Voltage Quantizer" by E. M. Glaser and H. Blasbalg, "A Digital Converter" by J. B. Speller, and "Efficient Linkage of Graphical Data with Digital Computers" by E. D. Lucas, Jr. The second session on computer circuits and components, contains three papers: "Transistor Flip-Flops for High-Speed Digital Computer Appli-

cations" by E. U. Cohler, "Design Fundamentals of Photographic Data Storage" by C. L. Hollander, and "Pulse Responses of Ferrite Memory Cores", by J. R. Freeman. Six papers composed the final session on digital computer systems: "Computer-Programmed Preventive Maintenance for Internal Memory Sections of the Era 1103 Computer System" by S. R. Gray, "An Input-Output System for a Digital Control Computer" by L. P. Retzinger, Jr., "Characteristics of a Logistics Computer" by Eugene Leonard, "The Dico 20 Digital Differential Analyzer (Abstract)" by Floyd Steele, and "The Bendix G-15 General Purpose Computer" by H. D. Huskey and D. C. Evans.

Controllership Foundation, Inc. / Business Applications of Electronic Machines: An Annotated Bibliography / Controllership Foundation, Inc., One East 42 St., New York 17, N. Y. / 1954, printed, 46 pp, $1.50 to members of the Controllers Institute of America, $2.00 to non-members

Following a three page suggested basic reading list, this pamphlet contains four sections devoted to electronics, advanced transitional uses of electromechanical equipment, machine manufacturers and installations and a listing of educational training programs, seminars and conferences.

Weiss, E. B. / "Cybernetics and Automation"/ "Advertising Age", 200 East Illinois Street, Chicago 11, Ill. / 1953, reprint, 16 pp, 35¢

This is a reprint of a series of four articles that appeared in Advertising Age in the four weekly issues of October 1953. The first article describes the "new science" of cybernetics and an over-all view of its effect on the economy. The second article discusses the application of cybernetics to factory, office and warehouse. The third paper goes into the ramifications of cybernetics on selling, merchandising and advertising. Finally, a long-range view of the effects on retailing is presented.

Bendiner, Robert / "The Age of the Thinking Robot and What It Will Mean to Us" in "The Reporter", April 7, 1955 / The Reporter, 220 East 42 St., New York 17, N. Y. /reprinted, 7 pp, 25¢

Deals with the coming age of automation and the employment problems which may arise. Problems considered and discussed are immediate and long-range, technological and psychological, all from the point of view of management and of labor. The demands of automation on future college programs are considered.

Schaefer, David H. / "A Rectifier Algebra" Paper No. 54-516 / American Inst. of Electrical Engineers, 33 West 39 St., New York 18, N. Y. / August 30, 1954, lithographed, 7 pp, 30¢ to members, 60¢ to nonmembers

This is an expository presentation of an algebraic system designed to simplify the analysis of circuits containing rectifiers and resistors. The system is synthesized from Boolean algebra and the infinite-valued logic of Lukasiewicz and Tarski. Examples of application are included.

Henderson, Alexander, and Robert Schlaifer / "Mathematical Programming: Better Information for Better Decision-Making" in "Harvard Business Review", May-June 1954/ Harvard Business Review, Soldiers Field, Boston 63, Mass. / 1954, printed, pp. 73-100, $8.00 annually, $2.00 per copy

Termed a "pioneering article," this paper describes the new technique of mathematical (linear and otherwise) programming in terms familiar to the executive and administrator. Part I, aimed at the top executive, provides the basic principles. Part II, the lengthiest section, contains a series of case examples which are supplemented in the appendix with specific programming directions. The third and final part is designed to illustrate how mathematical programming may be used as a planning tool for management. It describes how certain cost and profit information may be obtained as a basis for making sound decisions on both short-run and long-range problems.

Higgins, John A., and Joseph S. Glickauf/"Electronics Down to Earth" in "Harvard Business Review", March-April 1954 / Harvard Business Review, Soldiers Field, Boston 63, Mass./ 1954, printed, pp 97-104, $8.00 per year, $2.00 per copy

Written by a team of management consultants, this article discusses the ramifications of installing and operating a large-scale digital computer for business applications. After a brief résumé of some of the characteristics of a large computer, the authors discuss the economic advantages and provide criteria for evaluating the applicability of a computer in a given situation. Some misconceptions regarding computer size, printing speed and the need for radical changes in procedure are dispelled. The authors conclude that "the business risk (of an installation) may well be greater on the side of waiting than on the side of too rapid an approach."

Perry, J. W., Allen Kent, M. M. Berry and F.U.

Luehrs, Jr. / "Machine Literature Searching" in "American Documentation", Vol. V and VI / American Documentation Institute, Western Reserve University, 11111 Euclid Ave., Cleveland 6, Ohio / 1954-5, photooffset, 39 pp, $6.00 per year, $2.50 per copy

This series of seven papers, included in the one general title appears, in its several parts, under some permutation of some or all of the authors listed. The first part points out that it is possible to formulate the selection and correlation of information in order to take advantage of properly designed automatic equipment. Succeeding sections deal with the basic problems in indexing for machine searching and methods of classification amenable to automatic operation. Section IV is a partial collection of references to terminology in various technical fields. Contents of the final three papers are suggested by their titles: "Definition and systemization of terminology for code development," "Class definition and code construction," and "Machine functions and organization of semantic units."

Brown, R. Hunt / "Office Automation: Beginning of an Era" / Office Management, 212 5th Ave, New York, N Y / May & June, 1954, reprinted, 4 pp, free

Slow progress in office automation is partially laid to the gap between the businessman and the electronics manufacturer. The author proposes a number of guides for the business man to prepare for greater automation in office routines.

Brayer, Herbert O. / "The Truth About Electronic Business Machines" in "American Business", July, August, September, 1953 / 1953, reprinted

The first of the three articles in this series surveys the potentialities of electronic business machines and concludes that they will more likely produce an evolutionary change in business practices rather than a revolutionary one. The second part is devoted to a summary of the major companies making such machines and discussed development, prices, uses and installations. The third section lists various companies presently using modern, automatic equipment and describes methods of utilization and results accomplished.

END

Forum

AUTOMATIC PROGRAMMING OF PRODUCTION MACHINERY

Harmon G. Shively
B. F. Goodrich Co.
Akron, Ohio

We are interested in the automatic programming of several of our pieces of production machinery. Ultimately, this will include operating mixers or similar equipment for controlled periods of times at controlled speeds after they have been loaded with controlled amounts of several different kinds and types of raw materials.

Specifically, the job we want to consider now is one having a complete cycle time of approximately 150 seconds. The system adopted must allow this to be variable.

At different times throughout this cycle, 19 different operations will be performed beginning at various times during the cycle and lasting for periods of two to 30 seconds. In some cases, two or more of these operations may be going on at one time. The job has been done with a series of cams which close electrical contacts to cause these various functions to be performed. We desire to use some type of punched tape, like teletype tape, or a magnetic tape or drum, to control these various operations so that a new cam does not need to be cut each time the operation sequences are changed.

The programming equipment being considered will be required to close a circuit corresponding to that closed by the switch operated by the cam mentioned in the preceding paragraph. Because the various functions are performed, in some cases, simultaneously and for various durations of time, one method would be to use a teletypewriter type of punched tape, and use 38 symbols in pairs, one to turn on and one to turn off the equipment, to control these 19 functions. One-sixth of a second per space on the tape would be satisfactory for our purpose. In some respects, one-tenth of a second per space would be better, except that it would make the tape loop required longer.

The equipment must be fail-safe, because some of these functions will start machinery. There must be no possibility of a false signal of any type causing the machinery to start at an unexpected time. One method to do this would, of course, be to use dual equipment with a coincidence circuit so that if both tapes did not request the same operation at the same time, nothing would happen. Synchronous motors driving sprocket keyed tapes, I believe, could accomplish this.

Any other suggestions for the automatic programming of this type of equipment will be greatly appreciated.

Specifically, we are interested in quotations of price and delivery on:

1. Reading equipment that will use eight hole teletypewriter tape at the rate of six characters per second, so equipped that each one of 50 possible characters will operate one relay. Twenty-five of the relays should be equipped or arranged so that they can be equipped with a hold circuit, so that once operated they will stay operated until released by a second relay. The remaining 25 functions should be equipped to operate as the second relays. We prefer hermetically sealed relays, and if a dust-proof case is available for the complete unit, please include this in the estimate. Quote originally on single tape equipment without the coincidence circuit. Please specify the number of cycles we may expect from one paper tape, and your recommendations for more durable tape, such as plastic or the like.

2. Same, except ten characters per second, eight hole tape. Include costs for 50 relays as above. Provide space so that the remaining 205 may be added at some future date.

3. An alternate that you may suggest such as magnetic tape or magnetic drum, six units wide, six characters per second.

4. Same, except eight units wide, ten characters per second.

In all cases, the output of the equipment need only function to close or open circuits now controlled by small micro switches.

We would like to consider punched tape for the initial equipment, because it can be read visually. Card programming, using either a single punched card or a deck of punched cards, has considerable appeal. We would like to have comments on these also.

This request for a quotation came not to "Computers and Automation" but to Berkeley Enterprises. It seems of general interest to computer people, and so we have published it.

-- Editor

PATENTS

Hans Schroeder
Milwaukee, Wisconsin

The following is a compilation of patents pertaining to computers and associated equipment from the Official Gazette of the United States Patent Office, dates of issue as indicated. Each entry consists of: patent number / inventor(s) / assignee / invention.

February 22, 1955: 2,702,666 / A H Dickinson, Greenwich, Conn / Int'l Business Mach Corp, New York, N Y / Multifrequency electronic multiplier
2,702,667 / H C Ford, Great Neck, R E Crooke, Little Neck, and W H Newell, New York, N Y / Sperry Corp / Aerial target position computer
2,702,857 / F B Berger, Watertown, Mass, and J S Allen, Santa Fe, N M / USA, Sec'y of the Navy / Electronic square root computer
2,702,885 / H Shapiro, Cambridge, Mass / USA, Sec'y of the Navy / Supersonic delay line

March 1, 1955: 2,703,201 / W Woods-Hill, Letchworth, and D T Davis, Wandsworth Common, London, England / Int'l Business Mach Corp, New York, N Y / Electronic divider
2,703,202 / J R Cartwright, Letchworth, England / Int'l Business Mach Corp, New York, N Y / Pulse operated counter
2,703,203 / A S Bishop, Novelty, Ohio / USA, Sec'y of the Navy / Electronic circuitry for solving linear differential equations.
2,703,368 / L R Wrathall, Summit, N J / Bell Tel Labs, Inc, New York, N J / Pulse regeneration circuit using transistors

March 8, 1955: 2,703,678 / G W Hopkins, San Leandro, Calif, and W A Holman, Phoenix, Ariz / Friden Calc'g Mach Co, Inc / Ring counter using thyratrons
2,703,867 / D L Arenberg, Rochester, Mass / USA, Sec'y of the Navy / Variable supersonic delay line
2,703,876 / D Edmundson, and E A Hall, Rugby, England / British Thomson-Houston Co, Ltd / Electrical apparatus for the integration of variable instantaneous measurements

March 15, 1955: 2,704,186 / K J Braun, Glenbrook, Conn / - / Apparatus for feeding and sensing statistical record cards
2,704,326 / W L Whitson, Takoma Park, Md, and J Rabinow and W B MacLean, Washington, DC/ USA, Sec'y of the Navy / Electrical integrator
2,704,336 / B Kazan, Long Branch, N J / USA, Sec'y of the Army / Pulse counter using an electron beam

March 22, 1955: (No applicable patents)

March 29, 1955: 2,705,108 / J J Stone, Jr, Clinton, Tenn / US Atomic Energy Comm / Electronic adder
2,705,282 / L C Parode, Hermosa Beach, and G O Young, Hawthorne, Calif / Hughes Aircraft Co / Pulse Integrator utilizing vacuum tubes

April 5, 1955: (No applicable patents)

April 12, 1955: 2,706,080 / C S Carney and E H Fritze, Cedar Rapids, Iowa / Collins Radio Co, Cedar Rapids, Ia / Means for shifting the apparent angular position of a resolver without physically turning the shaft
2,706,246 / H Klemperer, Belmont, Mass / Raytheon Mfg Co, Newton, Mass / Cathode ray type storage tube and circuit
2,707,247 / D H Jacobs, Wood Acres, and M May, Ashton, Md / D H Jacobs / Information storage by means of a bistable electronic circuit
2,706,264 / A E Anderson, Mountainside, N J / Bell Tel Labs, Inc, New York, N Y / Cathode ray type storage tube and circuit
2,706,270 / F G Steele, Manhattan Beach, Calif/ Nat'l Cash Register Co / Digital control system using a motor from which are derived controlling impulses

April 19, 1955: 2,706,597 / L P Crosman, Darien, Conn / Remington Rand Inc, New York, N Y / Carry impulse generator

April 26, 1955: 2,707,255 / R M Byrne, Akron, Ohio / Goodyear Aircraft Corp, Akron, Ohio / Chopper modulated electric motor servo amplifier

May 3, 1955: 2,707,591 / M May, Los Angeles, Calif / Hughes Aircraft Company / Multiple-stable-state storage devices
2,707,756 / U. Lamm and E. Uhlmann, Ludvika, Sweden / Allmanna Svenska Elektriska Aktiebolaget, Vasteras, Sweden / Circuit for finding the square root of the sum of two squares, using nonlinear elements

May 10, 1955: 2,708,257 / A V Bedford, Princeton, N J / Radio Corp of America / Anti-hunt circuit for electric motor follow-up system
2,708,258 / D H Westwood, Haddonfield, N J / Radio Corp of America / Anti-hunt circuit for electric motor follow-up system
2,708,267 / J A Weidenhammer, Poughkeepsie, N Y / Int'l Business Machines Corp, New York, N Y / Record conversion system using magnetic cores
2,708,720 / A E Anderson, Mountainside, N J / Bell Tel Labs, Inc, New York, N Y / Transistor trigger circuit

END

Forum

COLLECTION OF MATERIAL ON EXPLOITATION OF AUTOMATIC DIGITAL COMPUTERS

George E. Forsythe,
Library Committee,
Numerical Analysis Research,
Department of Mathematics
University of California
405 Hilgard Avenue
Los Angeles 24, California

We want the holdings of our library to be as complete as possible on the techniques devised for the exploitation of automatic digital computing machines, and on the scientific ideas behind them. This material is of the greatest importance, not only for the current assistance of researchers, analysts, and coders, but also for a permanent record of this mushrooming field.

We are therefore asking if you would please be generous with your time, and take the trouble to do the following:

1. Send one copy of any available old and current material of the following sorts to

Librarian, Numerical Analysis Research
University of California
405 Hilgard Avenue
Los Angeles 24, California

(a) Each issue of any serial publication you put out — e.g., quarterly progress reports, or numbered research reports.

(b) Manuals and notes on coding for a digital computer.

(c) Descriptions of individual codes and subroutines, with or without copies of explicit commands.

(d) Notes on methods, sequences of codes, etc., which you have found useful for solving various classes of problems, like those compiled in the University of Illinois Digital Computer Programs.

(e) Reprints, private publications, lecture notes, surveys, bibliographies, etc., on the theoretical background or computational practice in any field in which computing looks feasible. Examples include matrix algebra, computations involving discrete variables, differential and functional equations, sampling of distributions, zeros of polynomials, approximation of functions, nuclear physics, astronomical orbits, meterological forecasting, numerical simulation of physical or social systems, machine translation, information processing, linear programming, logistics, etc., etc., etc.

(f) Catalogues, lists of college and university courses and their descriptions, curricula, etc., relating to numerical analysis.

(g) Related material which you suspect we might want.

2. Put us on your widest distribution list for similar material as it becomes available.

If you would like us to reciprocate by sending you material, please let me know your desires, and I will see that you get it.

In case you haven't heard, this organization has taken over the important functions of the National Bureau of Standards Institute for Numerical Analysis, which is no longer in existence. Material addressed to the Institute for Numerical Analysis automatically comes to us, but should be sent to the new organization.

Thank you very much for your help.

* ——— * ——— *

NOTICES

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Address Changes: If your address changes, please notify us giving both old and new address, and allow three weeks for the change.

INDUSTRIAL ELECTRONICS CONFERENCE, DETROIT, SEPT. 28-29

A conference on industrial electronics will be held in Detroit, Michigan, September 28-29. This symposium, the "Industrial Electronics Conference - 1955" will be co-sponsored by the American Institute of Electrical Engineers and the Professional Group on Industrial Electronics of the Institute of Radio Engineers. It is expected that some 300 engineers will gather in Detroit during the two-day session to discuss automation, industrial measurement problems, and new control system applications. A total of sixteen papers have been tentatively scheduled for the four technical sessions to be held in the Auditorium of the Engineering Society of Detroit.

Co-chairmen of the conference are S. Sterling of S. Sterling Co. and H. S. Mika of Ford Motor Company. Official conference headquarters will be the Park Sheraton Hotel; Guido N. Ferrara is Chairman of the Hotel and Registration Committee. He can be contacted at 8106 West Nine Mile Road, Oak Park 37, Michigan. The registration fee will be $3.00. All registrants at the conference will receive copies of the PGIE Transactions which will contain the papers delivered at the meeting.

Forum

NATIONAL SIMULATION CONFERENCE, JAN., 1956

J. R. Forester
Arlington, Texas

The Dallas-Fort Worth Chapter of the Institute of Radio Engineers Professional Group on Electronic Computers (PGEC) will sponsor a National Simulation Conference in Dallas, Texas, on 19-21 January 1956.

The Conference will be devoted to simulation and associated computing techniques, and will include topics in (a) general simulation (mathematical, physical, logistic, etc.); (b) advances in computer design, techniques, and applications; and (c) methods of determining and improving the accuracy of analog solutions.

A general solicitation of papers will be made at a later date. It is expected that most of the papers will fall into the analog computer category, but papers on the use of digital computers in simulation will be strongly encouraged.

Further information can be obtained from J. R. Forester, 2104 Huntington, Arlington, Texas.

Forum

CORRECTION OF THE MAY ISSUE

R. Ford
Freeport, N. Y.

You have doubtless learned from your readers by now that you have a masthead goof in your May issue.

Despite your flights among the clouds of Computers, Automation, Cybernetics, Robots and Automatic Control, you managed to show a date line of April, rather than May, and issue 4, rather than five on your contents page.

Program error? Lack of feedback? A flip-flop that failed to flip and only flopped?

Lost among your resounding nomenclatures and the abstractions which are your stock in trade, you show a warm tendency to human error. It redeems you and shows that there are housekeeping problems even in Ivory Towers that have not yet been solved by electronic proofreaders.

The editor has nothing to say except guilty as charged. On page 3 of the May issue, please replace "April" by "May" and "no. 4" by "no. 5."

* ——— * ——— *

BULK SUBSCRIPTION RATES

These rates apply to subscriptions coming in together direct to the publisher. For example, if 5 subscriptions come in together, the saving on each one-year subscription will be 25 percent, and on each two-year subscription will be 33 percent. The bulk subscription rates, depending on the number of simultaneous subscriptions received, are shown below:

Table 1 -- Bulk Subscription Rates
(United States)

Number of Simultaneous Subscriptions	Rate for Each Subscription, and Resulting Saving to Subscriber: One Year	Two Year
10 or more	$3.00, 33%	$5.40, 40%
5 to 9	3.38, 25	6.00, 33
4	3.75, 17	7.00, 22
3	4.00, 11	7.50, 17
2	4.25, 5	8.00, 11

For Canada, add 50 cents for each year; outside of the United States and Canada, add $1.00 for each year.

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The kit is the outcome of five years of design and development work with small robots by Berkeley Enterprises, Inc., publisher of "Computers and Automation", with the assistance of Oliver Garfield.

With this kit and manual, you can easily make dozens of small electric brain machines that exhibit intelligent behavior. Each runs on one flashlight battery. All connections with nuts and bolts; no soldering required. Price, $15.95 -- returnable in seven days for full refund if not satisfactory.

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- Reasoning
- Syllogism Machine
- Intelligence Testing

<u>Cryptographic Machines</u>
- Secret Coder
- Secret Decoder
- Combination Locks

<u>Game Playing Machines</u>
- Tit Tat Toe
- Nim

<u>Arithmetic Machines</u> (Decimal and Binary)
- Adding Machine
- Subtracting Machine
- Multiplying Machine
- Dividing Machine
- Arithmetical Carrying

<u>Simple Circuits</u>
- Burglar Alarm
- Automatic Oil Furnace Circuit, etc.

<u>Puzzle Machines</u>
- The Space Ship Airlock
- The Fox, Hen, Corn, and Hired Man
- Douglas Macdonald's Will
- The Uranium Shipment and the Space Pirates

MANUAL

"GENIACS -- Simple Electric Brain Machines and How to Make Them" by Edmund C. Berkeley, published by Berkeley Enterprises, Inc., March, 1955, 64 pp. — Describes over 30 small electric brain machines that reason arithmetically or logically, solve puzzles, play games, etc. Each machine operates on one flashlight battery. Gives sufficient details so that each machine can be constructed with the materials in Geniac Kit No. 1, or with other materials.

PARTS LIST: 1 Manual
- 6 Multiple Switches, of a new design
- 1 Mounting Panel
- 1 Flashlight Battery
- 1 Battery Clamp
- 10 Flashlight Bulbs
- 10 Bulb Sockets
- 50 Feet of Insulated Wire
- Nuts, Bolts, Jumpers, and other necessary hardware

(NO SOLDERING REQUIRED -- COMPLETELY SAFE)

---------Mail this Request or a Copy of It------

Geniac Project, c/o Berkeley Enterprises, Inc.
36 West 11 St., S125, New York 11, N. Y.

Please send me Geniac Kit No. 1 and Manual. I enclose in full payment: ( ) $15.95, U. S. east of Mississippi; ( ) $16.95, elsewhere in U. S.; ( ) $17.95, outside U. S.
(If in good condition, it is returnable in seven days for full refund.) My name and address are attached.

ROSTER ENTRY FORMS

"Computers and Automation" publishes from time to time reference information of the following three types: (1) a who's who or roster of individuals interested in the computer field; (2) a roster of organizations active in the computer field; and (3) a classified directory or roster of products and services offered in the computer field. The last cumulative roster appeared in "The Computer Directory, 1955", the June 1955 issue of "Computers and Automation." If you are interested in sending information to us for these rosters and their supplements, following is the form of entry for each of these three rosters. To avoid tearing the magazine, the form may be copied on any sheet of paper; or upon request we will send you forms for entries.

(1) Who's Who Entry Form

1. Name (please print) ____________________
2. Your Address? ____________________
3. Your Organization? ____________________
4. Its Address? ____________________
5. Your Title? ____________________
6. YOUR MAIN COMPUTER INTERESTS?

( ) Applications
( ) Business
( ) Construction
( ) Design
( ) Electronics
( ) Logic
( ) Mathematics
( ) Programming
( ) Sales
( ) Other (specify): ____________________
____

7. Year of birth? ____________
8. College or last school? ____________________
9. Year entered the computer field? ____________
10. Occupation? ____________________
11. Anything else? (publications, distinctions, etc.) ____________________
____

(2) Organization Entry Form

1. Your organization's name? ____________________
2. Address? ____________________
3. Telephone number? ____________________
4. Types of computing machinery or components, or computer-field products and services that you are interested in?
____
____
5. Types of activity that you engage in:
( ) research
( ) manufacturing
( ) selling
( ) consulting
( ) other (please explain): ____________________
____
6. Approximate number of your employees? ________
7. Year when you were established? ____________
8. Any comments? ____________________
____

Filled in by ____________________

Title ____________________ Date ____________

(3) Product Entry Form

1. Name or identification of produce (or service)?
____
2. Brief description (20 to 40 words)? ________
____
____
____
3. How is it used? ____________________
____
4. What is the price range? ____________________
5. Under what headings should it be listed?
____
6. Your organization's name? ____________________
____
7. Address? ____________________
____

Filled in by ____________________

Title ____________________ Date ____________

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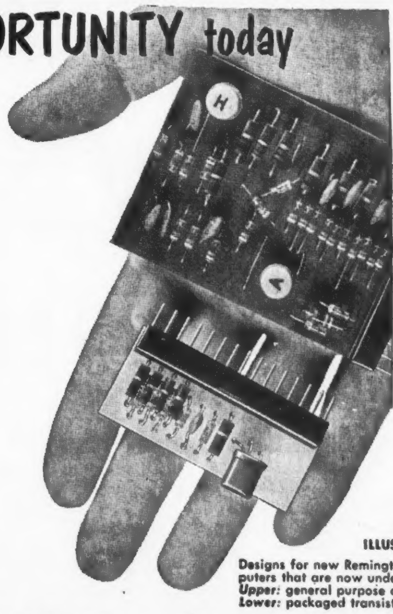

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You will work with the outstanding computer men who developed the ERA 1101, ERA 1102, and ERA 1103 Computer Systems, the Univac File Computer, ERA magnetic drum memories, and other equally famous Remington Rand systems.

Computer experience is not necessary. Your proficiency in related fields will be rewarded from the start, and you will work in the fastest-growing organization in the data-processing field. Opportunities for advancement will be numerous.

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Please send an outline of your training and experience to Mr. J. N. Woodbury:

REMINGTON RAND, Inc.

ENGINEERING RESEARCH ASSOCIATES DIVISION

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Forum:

LIKE RABBITS

Bill Danch
Munich, Germany

" -- My dear, everything is in readiness for our marriage: a fine rabbit hutch, a whole garden full of carrots, and an automatic computer to keep track of our progeny!"

COMPUTERS AND AUTOMATION — Back Copies

ARTICLES, ETC.: March, 1954: Towards More Automation in Petroleum Industries -- Sybil M. Rock
Introducing Computers to Beginners -- Geoffrey Ashe
Subroutines: Prefabricated Blocks for Building -- Margaret H. Harper
Glossaries of Terms: More Discussion -- Nathaniel Rochester, Willis H. Ware, Grace M. Hopper and Others

April: Processing Information Using a Common Machine Language: The American Management Association Conference, February, 1954 -- Neil Macdonald
The Concept of Thinking -- Elliot L. Gruenberg
General Purpose Robots -- Lawrence M. Clark

May: Ferrite Memory Devices -- Ephraim Gelbard and William Olander
Flight Simulators -- Alfred Pfanstiehl
Autonomy and Self Repair for Computers -- Elliot L. Gruenberg
A Glossary of Computer Terminology -- Grace M. Hopper

July: Human Factors in the Design of Electronic Computers -- John Bridgewater
What is a Computer? -- Neil Macdonald

September: Computer Failures -- Automatic Internal Diagnosis (AID) -- Neil Macdonald
The Cost of Programming and Coding -- C. C. Gotlieb
The Development and Use of Automation by Ford Motor Co. -- News Dept., Ford Motor Co.
Reciprocals -- A. D. Booth

October: Flight Simulators: A New Field -- Alfred Pfanstiehl
Robots I Have Known -- Isaac Asimov
The Capacity of Computers Not to Think -- Irving Rosenthal, John H. Troll

November: Computers in Great Britain -- Stanley Gill
Analog Computers and Their Application to Heat Transfer and Fluid Flow -- Part 1 -- John E. Nolan
All-Transistor Computer -- Neil Macdonald

December: The Human Relations of Computers and Automation -- Fletcher Pratt
Analog Computers and Their Application to Heat Transfer and Fluid Flow -- Part 2 -- John E. Nolan
Economies in Design of Incomplete Selection Circuits with Diode Elements -- Arnold I. Dumey

January, 1955: Statistics and Automatic Computers -- Gordon Spenser
Eastern Joint Computer Conference, Philadelphia, Dec. 8-10, 1954 -- Milton Stoller
The Digital Differential Analyzer -- George F. Forbes
A Small High-Speed Magnetic Drum -- M. K. Taylor
An Inside-Out Magnetic Drum -- Neil Macdonald

February: Problems for Students of Computers -- John W. Carr, III
Recognizing Spoken Sounds by Means of a Computer -- Andrew D. Booth
The Significiance of the New Computer NORC -- W. J. Eckert
The Finan-Seer -- E. L. Locke
Approaching Automation in a Casualty Insurance Company -- Carl O. Orkild

March: Question -- Isaac Asimov
Computers and Weather Prediction -- Bruce Gilchrist
Random Numbers and Their Generation -- Gordon Spenser
Problems Involved in the Application of Electronic Digital Computers to Business Operations -- John M. Breen
Computers to Make Administrative Decisions? -- Hans Schroeder

April: Thinking Machines and Human Personality -- Elliot L. Gruenberg
Marginal Checking -- An Aid in Preventive Maintenance of Computers -- J. Melvin Jones

May: Reliability in Electronic Data Processors -- William B. Elmore
Numerical Representation in Fixed-Point Computers -- Beatrice H. Worsley
Automation -- A Report to the UAW-CIO Economic and Collective Bargaining Conference
The Skills of the American Labor Force -- James P. Mitchell
Automation Puts Industry on Eve of Fantastic Robot Era -- A. H. Raskin
The Monkey Wrench -- Gordon R. Dickson

June: THE COMPUTER DIRECTORY, 1955 (164 pages):
Part 1: Who's Who in the Computer Field
Part 2: Roster of Organizations in the Computer Field
Part 3: The Computer Field: Products and Services for Sale

REFERENCE INFORMATION (in various issues):

Roster of Organizations in the Field of Computers and Automation / Roster of Automatic Computing Services / Roster of Magazines Related to Computers and Automation / Automatic Computers; List / Automatic Computers: Estimated Commercial Population / Automatic Computing Machinery: List of Types / Components of Automatic Computing Machinery: List of Types / Products and Services in the Computer Field / Who's Who in the Field of Computers and Automation / Automation: List of Outstanding Examples / Books and Other Publications / Glossary / Patents

BACK COPIES: Price, if available, $1.25 each. Vol. 1, no. 1, Sept. 1951, to vol. 1, no. 3, July, 1952: out of print. Vol. 1, no. 4, Oct. 1952: in print. Vol. 2, no. 1, Jan. 1953, to vol. 2, no. 9, Dec. 1953: in print except March, no. 2, and May, no. 4. Vol. 3, no. 1, Jan. 1954, to vol. 3, no. 10, Dec. 1954: in print. Vol. 4, 1955: in print.

A subscription (see rates on page 4) may be specified to begin with the current month's or preceding month's issue.

WRITE TO:

Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N. Y.

ADVERTISING IN "COMPUTERS AND AUTOMATION"

Memorandum from Berkeley Enterprises, Inc.
Publisher of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N.Y.

1. What is "COMPUTERS AND AUTOMATION"? It is a monthly magazine containing articles and reference information related to computing machinery, robots, automatic controllers, cybernetics, automation, etc. One important piece of reference information published is the "Roster of Organizations in the Field of Computers and Automation". The basic subscription rate is $4.50 a year in the United States. Single copies are $1.25. For the titles of articles and papers in recent issues of the magazine, see the "Back Copies" page in this issue.

2. What is the circulation? The circulation includes 1700 subscribers (as of June 20); over 300 purchasers of individual back copies; and an estimated 2000 nonsubscribing readers. The logical readers of COMPUTERS AND AUTOMATION are people concerned with the field of computers and automation. These include a great number of people who will make recommendations to their organizations about purchasing computing machinery, similar machinery, and components, and whose decisions may involve very substantial figures. The print order for the July issue was 2,300 copies. The overrun is largely held for eventual sale as back copies, and in the case of several issues the overrun has been exhausted through such sale.

3. What type of advertising does COMPUTERS AND AUTOMATION take? The purpose of the magazine is to be factual and to the point. For this purpose the kind of advertising wanted is the kind that answers questions factually. We recommend for the audience that we reach, that advertising be factual, useful, interesting, understandable, and new from issue to issue.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8½" x 11" (ad size, 7" x 10") and produced by photooffset, except that printed sheet advertising may be inserted and bound in with the magazine in most cases. The closing date for any issue is approximately the 10th of the month preceding. If possible, the company advertising should produce final copy. For photooffset, the copy should be exactly as desired, actual size, and assembled, and may include typing, writing, line drawing, printing, screened half tones, and any other copy that may be put under the photooffset camera without further preparation. Unscreened photographic prints and any other copy requiring additional preparation for photooffset should be furnished separately; it will be prepared, finished, and charged to the advertiser at small additional costs. In the case of printed inserts, a sufficient quantity for the issue should be shipped to our printer, address on request.

Display advertising is sold in units of full pages (ad size 7" x 10", basic rate, $170) and half pages (basic rate, $90); back cover, $330; inside front or back cover, $210. Extra for color red (full pages only and only in certain positions), 35%. Two-page printed insert (one sheet), $290; four-page printed insert (two sheets), $530. Classified advertising is sold by the word (50 cents a word) with a minimum of ten words. We reserve the right not to accept advertising that does not meet our standards.

5. Who are our advertisers? Our advertisers in recent issues have included the following companies, among others:

The Austin Co.
Automatic Electric Co.
Burroughs Corporation
Cambridge Thermionic Corp.
Federal Telephone and Radio Co.
Ferranti Electric Co.
Ferroxcube Corp. of America
General Ceramics Corp.
General Electric Co.
Hughes Research and Development Lab.
International Business Machines Corp.
Laboratory for Electronics
Lockheed Aircraft Corp.
Logistics Research, Inc.
Machine Statistics Co.
Monrobot Corp.
Norden-Ketay Corp.
George A. Philbrick Researches, Inc.
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Telecomputing Corp.

ADVERTISING INDEX

The purpose of COMPUTERS AND AUTOMATION is to be factual, useful, and understandable. For this purpose, the kind of advertising we desire to publish is the kind that answers questions, such as: What are your products? What are your services? And for each product: What is it called? What does it do? How well does it work? What are its main specifications? We reserve the right not to accept advertising that does not meet our standards.

Following is the index and a summary of advertisements. Each item contains: Name and address of the advertiser / subject of the advertisement / page number where it appears.

Berkeley Division, Beckman Instruments, Inc., 2200 Wright Ave., Richmond 3, Calif. / Engineers Wanted / page 25

Berkeley Enterprises, Inc., 36 West 11 St., New York 11, N.Y. / Geniac / page 33

Computers and Automation, 36 West 11 St., New York 11, N.Y. / Back Copies, Advertising / pages 38, 40

Electronics Corp. of America, 77 Broadway, Cambridge 39, Mass. / Engineers Wanted / page 28

Ferranti Electric Inc., 30 Rockefeller Plaza, New York 20, N.Y. / High Speed Tape Reader/ page 39

Ferroxcube Corp. of America, 377 East Bridge St., Saugerties, N.Y. / Magnetic Core Materials / page 39

Hughes Research and Development Laboratories, Culver City, Calif. / Engineers Wanted / page 41

Lockheed Aircraft Corp., Burbank, Calif./ Career Opportunities / page 5

Monrobot Corporation, Morris Plains, N.J. / Computer Components / page 2

Princeton University Press, Princeton, N.J./ Book, "Approximations for Digital Computers" / page 41

Remington Rand, Inc., ERA Division, 1902 W. Minnehaha Ave., St. Paul, Minn. / Engineers Wanted / page 35

Republic Aviation Corp., Farmingdale, L.I., N.Y. / Engineers Wanted / page 37

Richardson Camera Company, 171 West Magnolia Blvd., Burbank, Calif. / Film Reader / page 35

Sprague Electric Co., 377 Marshall St., North Adams, Mass. / Metallized Paper Capacitors/ page 44

Sylvania Electric Products, Inc., Missile Systems Laboratory, 151 Needham St., Newton, Mass. / Engineers Wanted / page 37

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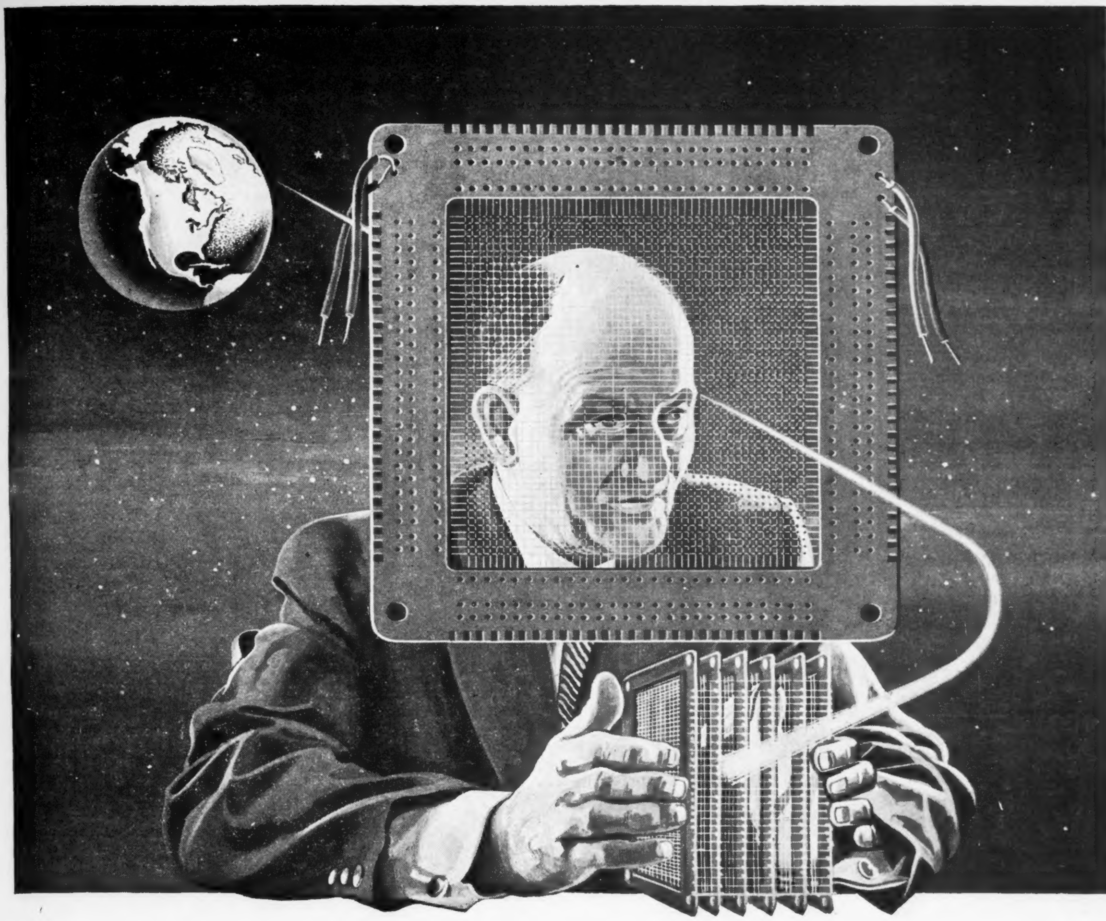
MANUSCRIPTS

We are interested in articles, papers, and fiction relating to computers and automation. To be considered for any particular issue, the manuscript should be in our hands by the fifth of the preceding month.

Articles. We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it. Consequently a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, details, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions. We look particularly for articles that explore ideas in the field of computers and automation, and their applications and implications. An article may certainly be controversial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 4000 words, and payment will be \$10 to \$40 on publication. A suggestion for an article should be submitted to us before too much work is done.

Technical Papers. Many of the foregoing requirements for articles do not necessarily apply to technical papers. Undefined technical terms, unfamiliar assumptions, mathematics, circuit diagrams, etc., may be entirely appropriate. Topics interesting probably to only a few people are acceptable. No payments will be made for papers. If a manuscript is borderline, it may be returned to the author to be modified to become definitely either an article or a paper.

Fiction. We desire to print or reprint fiction which explores ideas about computing machinery, robots, cybernetics, automation, etc., and their implications, and which at the same time is a good story. Ordinarily, the length should be 1000 to 4000 words, and payment will be \$10 to \$40 on publication if not previously published, and half that if previously published.



What's New in Mnemonics?

It's the new Univac II—the finest business computing system ever developed. The famous Univac of Remington Rand is still the *only* completely self-checking system . . . the only one which can read, write, and compute simultaneously. And now Univac adds to these superior features the speed of a magnetic-core memory.

Remington Rand has pioneered in this important new development, installing, over a year ago, the first commercially available electronic computer to use magnetic-core storage successfully.

Mnemonics, says Webster, is "the art of improving the efficiency of the memory." And, in electronic computing, the new Univac II carries this art to a point far beyond its contemporaries.

With this new magnetic-core storage, the internal memory of the Univac has doubled, giving instantaneous access to 24,000 alphabetic or numeric characters. If needed, the capacity of Univac II can be further increased to 120,000 characters.

Univac's external memory—magnetic tape—now has greater capacity too, increasing input and output to 20,000 characters per second . . . the equivalent of reading or writing every character on this page more than 1,000 times a minute.

These new Remington Rand developments can be incorporated into any existing Univac installation to double its speed of operation and increase its economy still further. For additional details, write to . . .

Remington Rand INC

ELECTRONIC COMPUTER DEPARTMENT, ROOM 1743, 315 FOURTH AVENUE, NEW YORK 10, NEW YORK

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